FLEET TECHNOLOGY LIMITED

3905C.FR

RESULTS OF TWO TESTS CONDUCTED TO EVALUATE THE WEAR RESISTANCE OF CONCRETE DUE TO ICE ABRASION

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PROJECT TEAM

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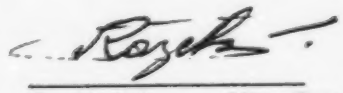
DISCLAIMER

The contents of this report reflect the views of Fleet Technology Limited and not necessarily the official views or opinions of the Department of Energy, Mines and Resources.

APPROVED BY: 

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1.0 INTRODUCTION

The wear resistance of concrete to abrasion by ice is of concern for concrete structures placed in ice-infested waters. At present, there is paucity of data to evaluate this issue. Furthermore, appropriate procedures and test methods for evaluating concretes are not yet standardized or calibrated with field experience. Recently, a method was developed to evaluate the wear resistance of concrete due to ice abrasion in the laboratory (Roots et al, 1986). A number of test programs have since been carried out to build up a database using this method (Arctec Canada Ltd., 1987, Comfort, 1989 a;b, Comfort, 1990). This report documents the results of two more tests which were conducted to expand the available database.

2.0 TEST METHODS AND MATRIX

2.1 Test Apparatus and Approach

The tests were conducted in Fleet Technology Limited's cold room in Kanata, Ontario using a test machine that had been previously developed for concrete abrasion testing. This test machine is shown in plates 2.1 and 2.2 and described further in Roots et al, 1986 and Comfort, 1989 a;b.

Abrasion-only tests were conducted during this test program by continuously rotating the concrete specimens while an ice block was pressed against them. The contact force was held constant (at 14 kN) and the rotational speed of the cylinders was maintained at 43.6 revolutions per minute (which produces a tangential speed of 0.7 m/s (2.5 km/hr) at the concrete-ice interface). Ice blocks were replaced as required during this test. A total of ten ice blocks were used during each test which produced a total duration of 164 and 146 hours for the two tests conducted. The reader is referred to Comfort, 1989 a;b for further description of this test method.

2.2 Test Documentation

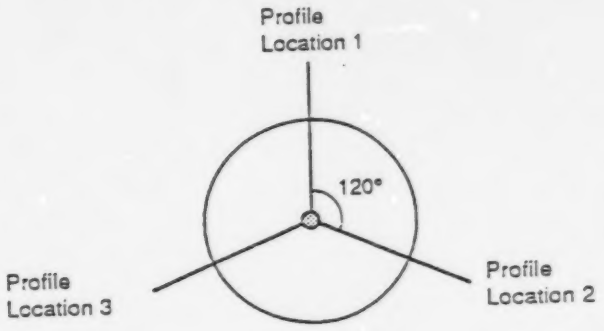
Wear measurements were made three times over the duration of the tests. These were done when the tests were 1/3 complete, 2/3 complete and fully complete. These measurements were made using a digital profiler, with a measurement accuracy of 5μm, and a locating frame that allowed the wear measurements to be referenced to a baseline established on the concrete cylinder. The wear measurements were made by profiling the cylinders at three equally-spaced longitudinal profile locations (e.g., 120 degrees apart). Ten equally-spaced depth measurements were made along the length of each profile and the measurements made at each profile location were repeated three times. This measurement approach is shown schematically in Figure 2.1 and described further in Comfort, 1989 a;b.

The concrete specimens were photographed to document their surface condition at the start and end of the tests.

The displacement of each ice block was monitored and plotted continuously as a function of time for each test. This information was used to document the wear rate of the ice block and the duration of the test. A sample output is shown in Figure 2.2.

Concrete Abrasion
Test Machine
Plate 2.1

Plate 2.2
Concrete Abrasion
Test Machine



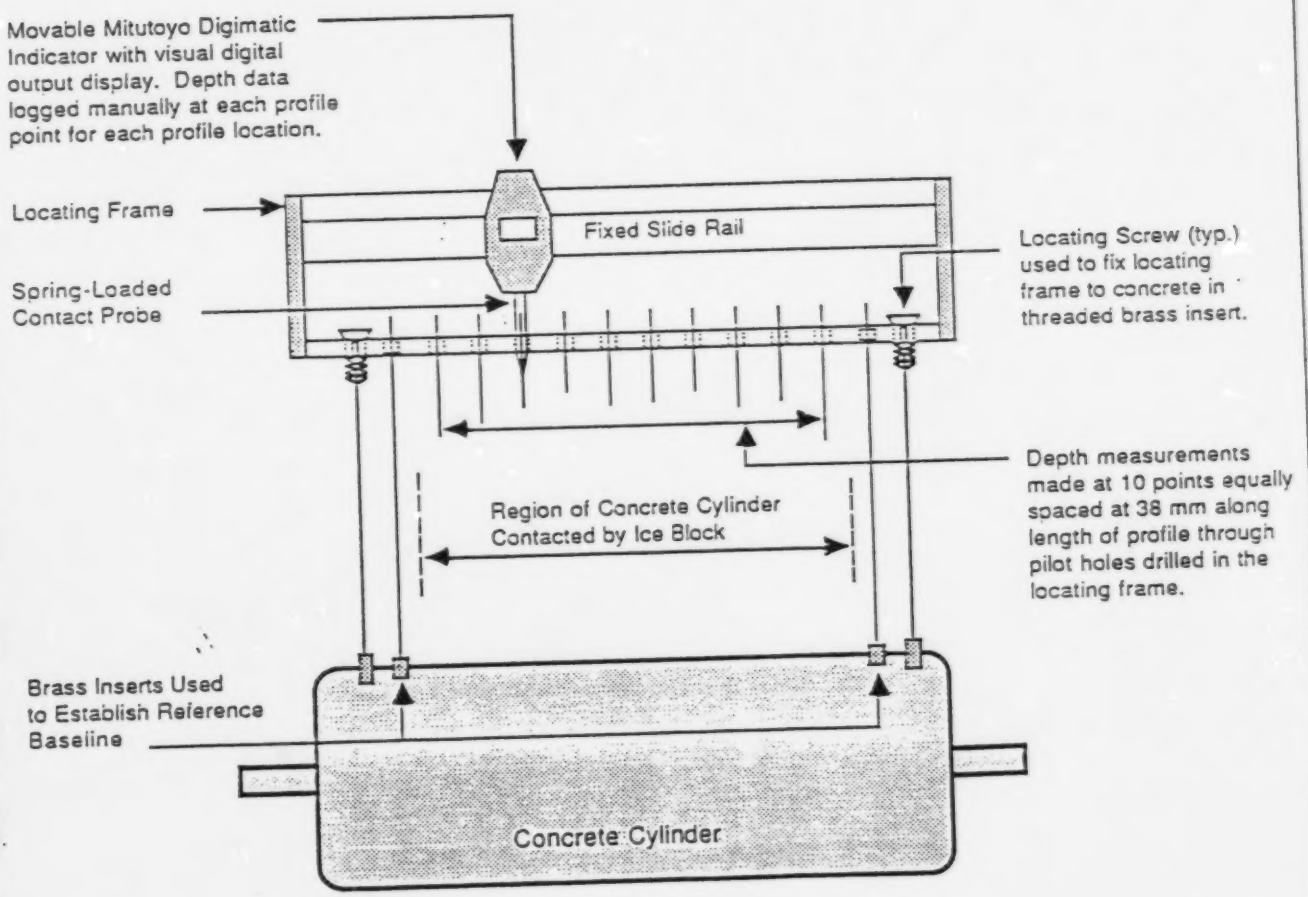
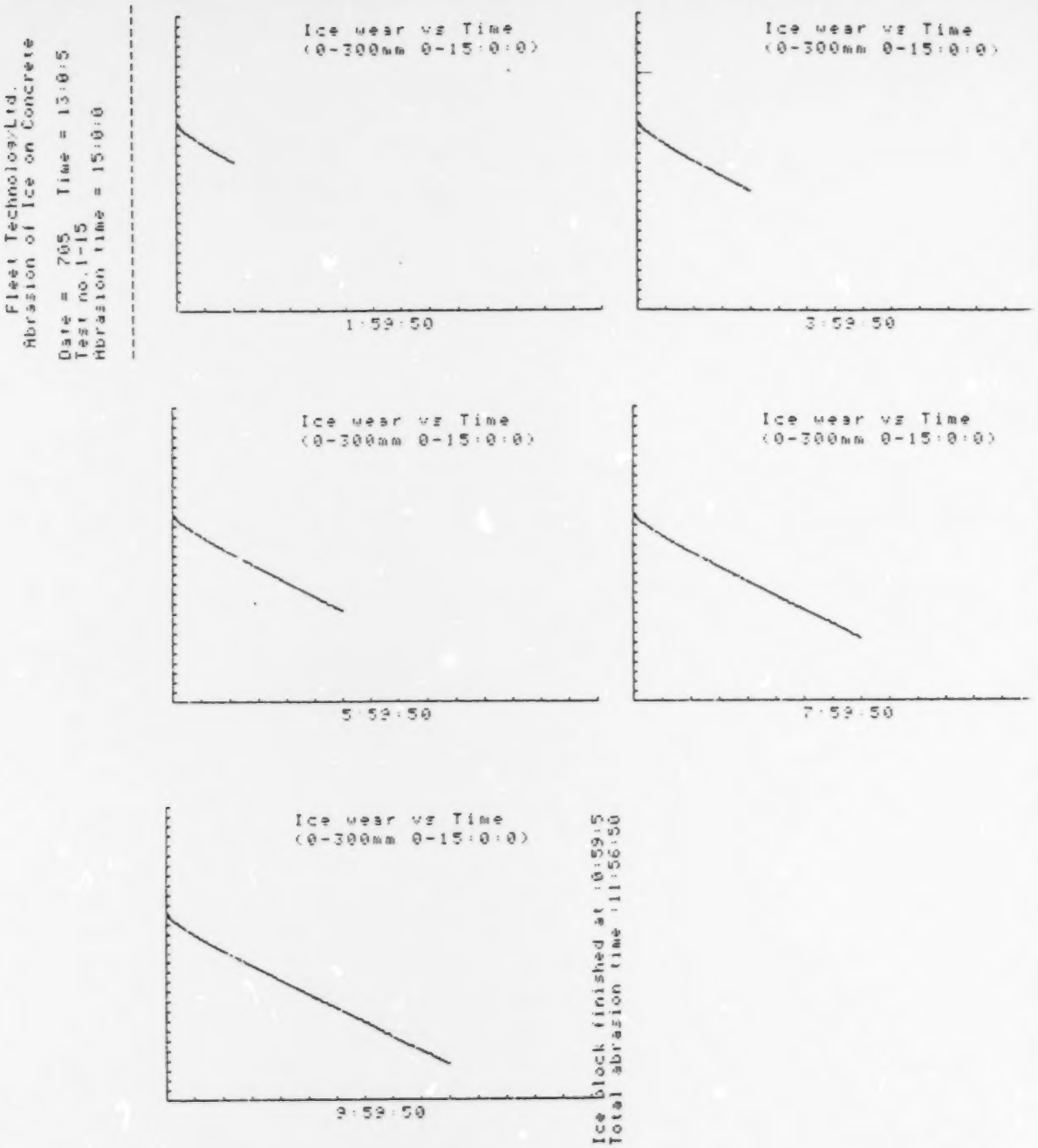

Movable Mitutoyo Digimatic Indicator with visual digital output display. Depth data logged manually at each profile point for each profile location.
Locating Frame
Fixed Slide Rail
Locating Screw (typ.) used to fix locating frame to concrete in threaded brass insert.
Spring-Loaded Contact Probe
Depth measurements made at 10 points equally spaced at 38 mm along length of profile through pilot holes drilled in the locating frame.
Region of Concrete Cylinder Contacted by Ice Block
Brass Inserts Used to Establish Reference Baseline
Concrete Cylinder

Figure 2.1 Schematic of Approach Used to Measure Wear Of the Concrete Cylinders

(after Comfort, 1989a)



Ice Block #1
Test #1

Figure 2.2
Wear Of A Typical Ice Block During A Test

2.3 Description of Concrete Specimens

Concrete specimens were produced for the test program by Concrete Laboratory Ltd. Table 2.1 summarizes the mixtures from which the specimens were cast and the measured mechanical properties of these concretes. More detailed information is provided in Appendix C.

Rebound hammer and ultrasonic pulse velocity tests were conducted by CANMET before and after the abrasion tests to provide additional information. Summary results are presented in Table 2.2. More detailed information is provided in Appendix C.

Two concrete cylinders were cast from each mixture for abrasion testing. One of these cylinders was cast with a smooth surface finish while the other had a textured surface finish. These surface finishes are similar to those of the cylinders tested in previous abrasion test programs. (See Arctec, 1987 and Comfort, 1989 a;b, for description.) Each abrasion test was carried out with one "smooth" and one "textured" concrete cylinder.

Table 2.1 Description of Concrete Used for Specimens (after A. Bisaillon, Concrete Laboratory Ltd. - See Appendix C for more detailed information)

Date of casting	04/27/90	04/30/90	05/02/90	05/04/90
Concrete strength MPa	15	25	45	35
FORMULA (kg/m^3) 6236-	06	07	08	09
Cement	245	323	571	426
Water	183	190	206	193
Coarse agg. 20 mm	308	320	320	325
Coarse agg. 14 mm	480	499	501	508
Coarse agg. 10 mm	961	849	631	792
Sand	173	180	180	183
W/C	0,745	0,551	0,362	0,452
RESULTS				
Slump (mm)	60	120	120	110
Air content (%)	4,0	3,0	2,2	2,8
Temperature (°C)	20	21	20	21
Unit weight (kg/m^3)				
Theoretical	2350	2385	2400	2390
Fresh	2350	2360	2410	2427
14 days	2385	2384	2416	2414
Compressive Strength, MPa				
3 days	7,5	15,7	31,0	25,4
	7,7	15,9	34,1	25,4
	7,8	16,3	34,5	26,6
7 days	11,7	24,7	36,6	28,8
	12,9	25,9	37,3	29,2
	12,9	26,3	39,3	32,4
28 days	18,8	30,7	47,3	37,8
	19,5	32,0	48,3	40,0
	19,8	32,9	49,3	40,7
91 days	20,3	31,5	47,5	41,5
	20,8	33,7	49,8	42,8
	21.3	34.6	50.3	44.8
Extra cylinders	175 d	100 d	134 d	168 d
	23,5	34,0	49,8	42,7
	24,4	34,0	53,3	43,2
	24,6	36,0	55,4	45,3
Modulus of elasticity, MPa X 10^6				
28 days	29030	28830	30805	27135
	26450	31210	32240	32500
Average	27740	30020	31520	29820
Poisson's ratio				
28 days	0,25	0,23	0,24	0,21
	0,23	0,21	0,26	0,26
	0,24	0,22	0,25	0,24

TABLE 2.2

SUMMARY IN-SITU TEST RESULTS
(TESTS CONDUCTED BY CANMET)

Concrete Mix No.	Nominal Compressive Strength (Mpa)	Surface Finish	Range of Mean Rebound Numbers for Each Profile Location		Range of Mean Ultrasonic Pulse Velocities (m/s) for Each Profile Location	
			Before Abrasion Test	After Abrasion Test	Before Abrasion Test	After Abrasion Test
6	15	Smooth Textured	28-29 20-21	19-22 19-21	4465-4620 4495-4605	4030-4235 4095-4190
7	25	Smooth Textured	30-33 22-23	26-29 21-22	4515-4640 4535-4585	4140-4190 4355-4410
9	35	Smooth Textured	34-36 23-24	33-39 24-27	4535-4610 4570-4630	4605-4690 4650-4690
8	45	Smooth Textured	39-41 24-25	34-40 23-28	4690-4710 4630-4815	4615-4700 4650-4690

2.4 Environmental Test Conditions

2.4.1 Ice Properties

The tests were done using simulated sea ice that was grown in tanks in the cold room. This was accomplished using standard procedures, which included adding salt to the water, skimming the first ice growth and seeding to produce rapid initiation of vertical ice growth. For further description of these procedures, the reader is referred to Arctec, 1987.

The properties of the ice samples are summarized in Table 2.3.

2.4.2 Air Temperature

All tests were conducted at an ambient air temperature of -12°C.

2.4.3 Water Bath Temperature

All tests were conducted with a water bath temperature of +0.2°C.

2.5 Test Matrix

A total of four tests were conducted with the concrete specimens that were produced, and that are described in Section 2.3. Tests 1 and 2 were funded by the Mobil Research and Development Corporation and are reported separately (Comfort, 1990). Tests 3 and 4 were supported by CANMET and are reported herein.

Table 2.4 describes the matrix for all four tests.

TABLE 2.3
ICE PROPERTIES SUMMARY

Temperature: -12°C

Salinity Profile:

Depth From Top Surface (cm)	Measurement Profile #		
	1	2	3
0-5	3.2	3.0	3.4
5-10	3.1	3.3	3.0
10-15	3.1	2.9	3.2
15-20	2.7	2.8	2.8
20-25	2.9	2.6	2.9
25-30	2.8	2.6	2.8
30-35	2.7	2.6	2.8
35-40	2.9	3.1	2.8
40-45	3.2	3.5	3.1
45-50	4.3	3.6	4.2
50-55	4.4	4.2	4.3
55-60	4.2	4.1	4.0
60-65	4.0	4.0	3.5
65-70	4.0	3.9	3.7

Density = 0.91 g/cc

Orientation of Vertical Crystals with respect to the Longitudinal Axis of the Concrete Cylinder.

The ice samples were cut and positioned such that their direction of growth (in the tank) was parallel to the longitudinal axis of the concrete cylinders. This aligned the ice crystals in the vertical direction with the longitudinal axis of the cylinders.

TABLE 2.4

TEST MATRIX

Test # (See Note)	Test Date	Concrete Specimens				Test Type	Total Test Duration (Hrs)
		Mixture #	Nominal 28 Day Comp. Strength (Mpa)	Specimen Surface			
				Textured	Smooth		
1	July 15-August 3	6	15	✓	✓	Abrasion Only	118
2	August 7-August 24	7	25	✓	✓	Abrasion Only	131
3	August 8-Sept 7	9	35	✓	✓	Abrasion Only	164
4	Sept 10-Sept 24	8	45	✓	✓	Abrasion Only	146

Note: Tests 1 and 2 were funded by the Mobile Research and Development Corporation and are reported separately in Comfort, 1990. Tests 3 and 4 were funded by CANMET and are reported herein.

Test Parameters:

Rotational Speed of concrete cylinders: Held constant at 43.6 rpm which produces a tangential speed of 2.5 km/hr at the ice-concrete surface.

Contact force between the ice block and the concrete cylinders: Held constant at 14.0 kN.

Ice properties: All tests conducted using simulated sea ice (of 3-4 ppt salinity and 0.91 g/cc density).

Ambient Air Temperature: Held constant at -12°C.

Waterbath Temperature: Held constant at +0.2°C

3.0 TEST RESULTS

3.1 Qualitative Test Results

The concrete cylinders were visibly damaged during both tests. The condition of the specimens at the end of Tests 3 and 4 are shown in plates 3.1 to 3.4, and 3.5 to 3.8, respectively. For both tests, surface damage was significantly more extensive for the smooth-surfaced specimen than for the specimen with a textured surface. However, the extent of the surface damage was generally similar for specimens of similar surface finish for both tests. See Table 3.1.

Surface damage occurred progressively during each test. Usually, damage commenced with a small break in the surface finish which was either present at the start of the test or was ice-induced. Damage then progressed relatively quickly as these breaks tended to both deepen and to grow in area. As a result, damage and wear occurred unevenly over the surface of the specimen. At the end of the test, aggregates were removed from the concrete by the ice. In some cases, these aggregates became embedded in the ice block which probably accelerated the wear process.

Surface damage was least extensive for the textured, Test 4 specimen. A small amount of wear occurred during this test for this sample. However, the surface finish was not broken and aggregate was not exposed. Hence, the measured wear reflects abrasion of the surface asperities of this specimen. See plate 3.8.

3.2 Quantitative Test Results

Table 3.2 summarizes the wear measurements which were made during both tests. Appendices A and B present the raw and reduced data on which Table 3.2 is based. Table 3.2 shows that the measured wear varied significantly for different profile locations in some cases. This was especially noticeable in cases where wear occurred unevenly over the surface of the specimen.

Figure 3.1 summarizes the wear which occurred during this test program. For all tests, the average wear was small and did not exceed 1 mm. This is similar to the results of previous concrete abrasion test programs. See figure 3.2. During both tests, the wear was greater for the smooth specimens than for the textured ones.

Plate 3.1
Smooth-surfaced
Test #3 Specimen
At End of Test

Plate 3.2
Textured Test #3
Specimen at End
of Test

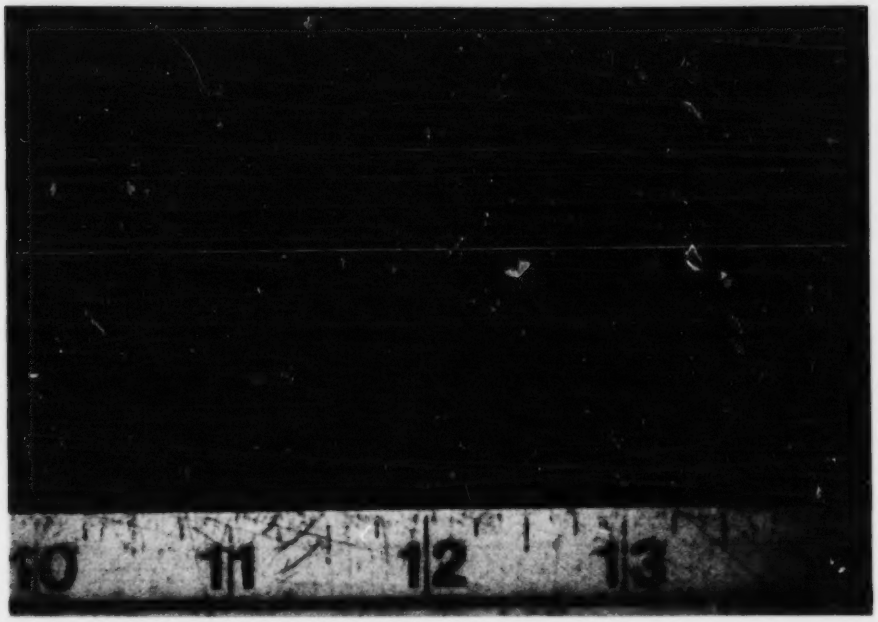


Plate 3.3
Closeup of Smooth-surfaced Test Specimen At End of Test (Scale in Inches)

Plate 3.4
Closeup of Textured Test #4 Specimen at End of Test (Scale in Inches)

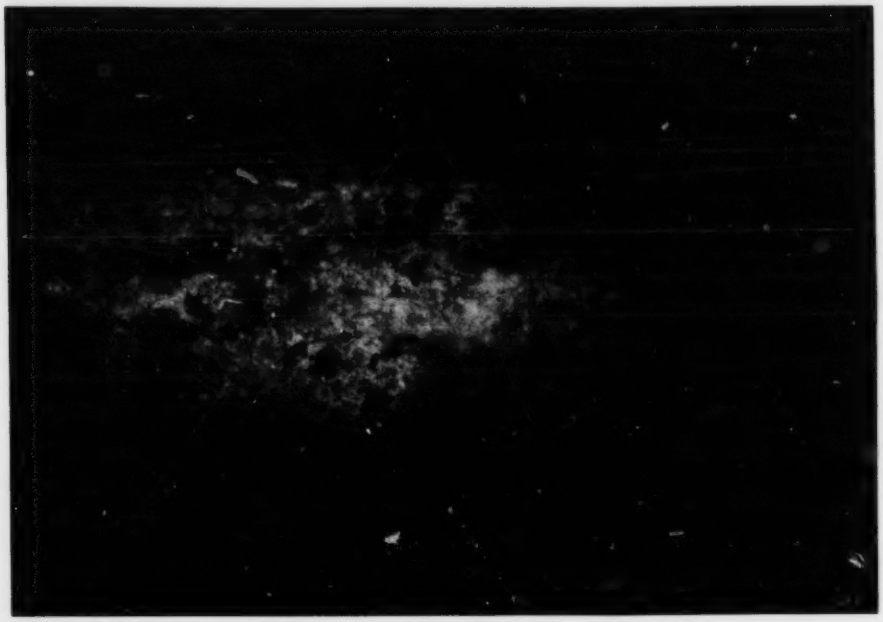


Plate 3.5
Test #4 Smooth-surfaced Specimen At End of Test

Plate 3.6
Test #4 Textured Specimen At End of Test

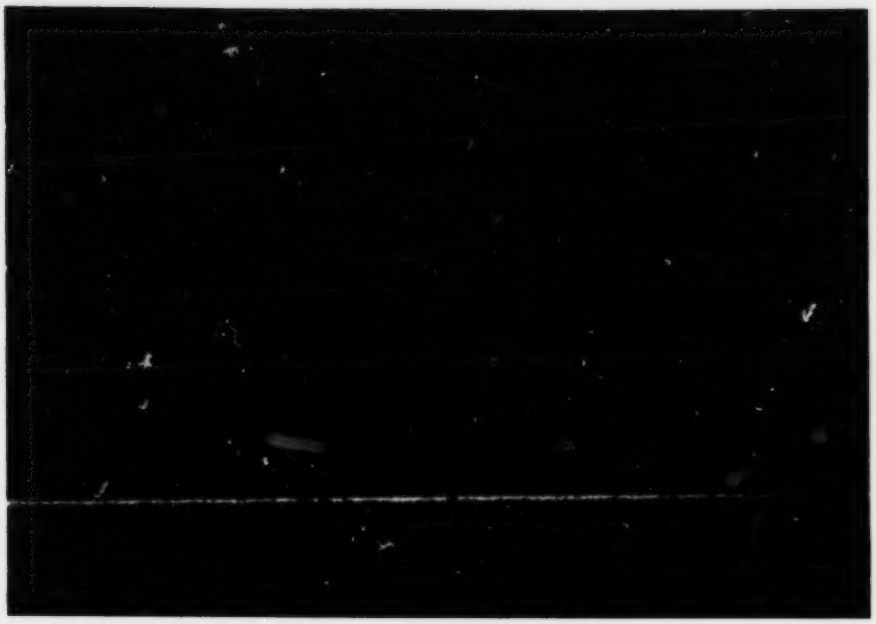


Plate 3.7
Closeup of Test #4
Smooth-surfaced
Specimen At End of
Test (Scale in
Inches)

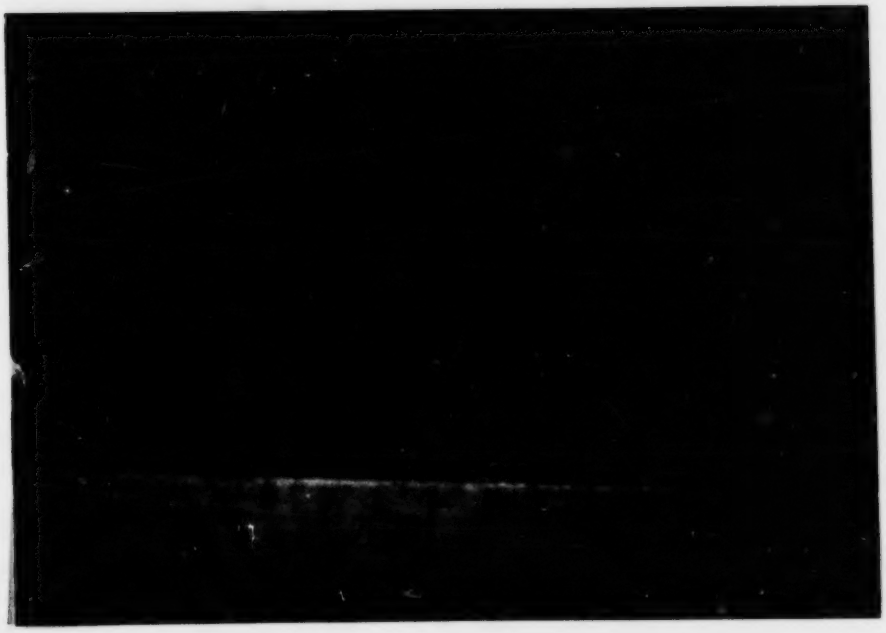


Plate 3.8
Closeup of Test #4
Textured Specimen
At End of Test
(Scale in Inches)

TABLE 3.1

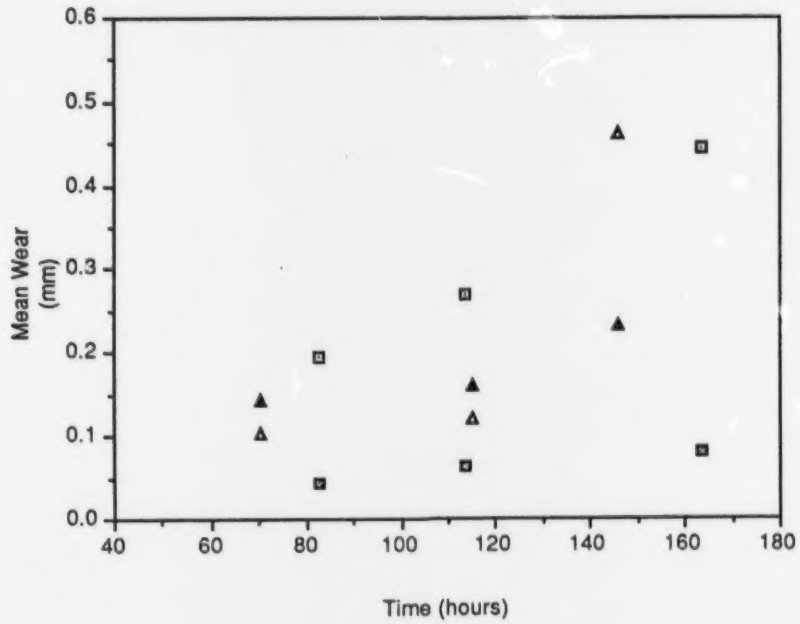
DAMAGED SURFACE AREA SUMMARY

Test #	% of Total Surfacve Area That Was Visibly Damaged at the End of the Test	
	Smooth-Surfaced Specimen	Textured Specimen
3	35	5
4	30	1

TABLE 3.2
SUMMARY OF WEAR MEASUREMENTS

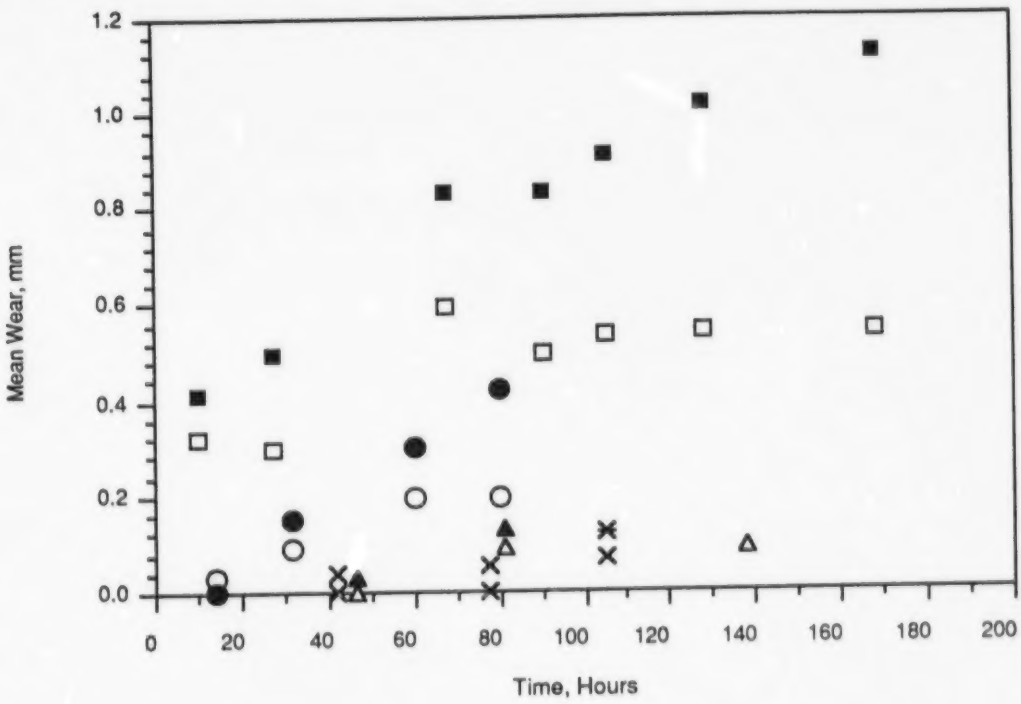
Test #	Sample #	Nom. 28 Day Comp. Strength (MPa)	Cum. Hours of Abrasion	Mean Measured Wear (mm) - See Note 1 Below							
				TEXTURED CYLINDER				SMOOTH CYLINDER			
				Profile Location				Profile Location			
				Average for Location #			Avg. of All 3 Locations	Average for Location #			Avg. of All 3 Locations
				1	2	3		1	2	3	
3	9-A	35	82.6	.034	.031	.063	.043	.039	.239	.306	.195
	9-B		113.6	.026	.062	.097	.062	.081	.395	.334	.270
			163.5	.060	.056	.125	.080	.129	.412	.794	.445
4	8-A	45	70.3	.140	.033	.258	.144	.116	.164	.028	.103
	8-B		115.3	.167	.048	.269	.161	.141	.173	.048	.121
			145.9	.261	.063	.376	.233	.708	.352	.330	.463

Note 1: Depth measurements were made at ten points with three repetitions each along the length of the concrete cylinder at each profile location. The average wear along the profile was computed for each set of profile measurements based on the area of the profile with respect to that of the baseline profile. These values (of the average wear along the length of the profile) were averaged to produce the averages listed above for each profile location.



Symbol	Concrete Mix No.	Nom. 28 day Comp. Strength (MPa)	Concrete Surface
□	9	35	Smooth
■	9	35	Textured
△	8	45	Smooth
▲	8	45	Textured

Figure 3.1: Abrasion Test Results



Data Source and Test #	Concrete Mix Series	Concrete Strength (MPa)	Concrete Surface	Test Type
■ 1 (after Roots et al, 1986)	I	35	Smooth	Abrasion Only
□ 2 (after Roots et al, 1986)	III	65	Smooth	Abrasion Only
● 3 (after Roots et al, 1986)	I	35	Smooth	Impact/Abrasion-Sequence B
○ 4 (after Roots et al, 1986)	III	65	Smooth	Impact/Abrasion-Sequence B
▲ 6 (1989 test series)	II	50	Rough	Abrasion Only
△ 6 (1989 test series)	II	50	Smooth	Abrasion Only
× 7 (1989 test series)	II	50	Rough	Impact/Abrasion-Sequence C
✱ 7 (1989 test series)	II	50	Smooth	Impact/Abrasion-Sequence C

Sequence B Description (after Roots et al, 1986):
50 impacts @ 1 m/sec
Repeated 5 times over duration of test and separated by abrasion periods.

Sequence C Description: *50 impacts (nominal) @ 1 m/sec*
Impacts separated by abrasion periods of 10 hours (nominal value).

Note: Negative wear measurements were plotted as zero values.

Figure 3.2 Abrasion Test and Sequential Impact-Abrasion Test Results
(after Comfort, 1989b)

4.0 RECOMMENDATIONS

The test results obtained to date have provided some insight into concrete wear due to ice abrasion and impact. While it is encouraging that some visible surface damage occurred during this past test program (in contrast to the 1989 test program (Comfort 1989 a;b)), we believe that the present test is not a very severe one and that modifications to the test technique are required. We suggest that:

(a) Freeze-thaw tests be done on the concrete specimens before they are tested for ice abrasion. Freeze-thaw tests will weaken the bond between the cement paste and the aggregate which is important for the initiation of damage. During this study, it was noted that surface damage occurred progressively, starting with a break in the surface finish of the concrete. Once a break occurred, holes tended to both deepen and to grow in area relatively quickly. Hence, if freeze-thaw tests are first conducted, it is expected that the concrete will undergo greater damage and wear during the subsequent ice abrasion tests. This test sequence is also expected to be more representative of service conditions for an offshore structure as the concrete at this site will be subjected to both freeze-thaw and to ice abrasion.

(b) The normal pressure between the ice and the concrete be increased. With the present test technique, the normal pressure is about 100 kPa (see Comfort, 1989 a;b). This may be representative of pressures for the case where loose ice floes slide past a structure; however, this pressure is much lower than local ice failure pressures (which are expected to be in excess of 1 mPa). We believe that tests at these higher pressures will be more representative of conditions for an offshore structure as we expect that the greatest wear and damage will occur when ice is failed against it.

(c) The initial surface finish of the concrete specimens be damaged (e.g., by mechanical means) before they are tested for ice abrasion. This simulates the case where the surface condition of the concrete at an offshore structure has become degraded, which is a possibility that can occur over the life of the structure. This is expected to result in more wear to the concrete during the test as damage tended to occur progressively following a break in the surface and, in many cases, the surface finish of the concrete was in the process of being damaged when the test had to be terminated. As a result, little wear occurred in some tests, particularly for the stronger concretes.

If the specimen's surface finish is damaged prior to the start of the test, more wear will likely occur which will provide a more measurable means for comparing various concretes. Also, it will probably reduce the required duration of the test, and hence, the cost of the test.

5.0 REFERENCES

[1] Comfort, G., 1989a, Results of Five Tests Conducted to Evaluate the Wear Resistance of Concrete Due to Ice Abrasion and Impact, Fleet Technology Limited Report 3238 submitted to the Mobile Research and Development Corporation.

[2] Comfort, G., 1989b, Results of Two Tests Conducted to Evaluate the Wear Resistance of Concrete due to Ice Abrasion and Impact, Fleet Technology Limited report 2312 submitted to CANMET of the Department of Energy, Mines and Resources.

[4] Arctec Canada Limited, 1987, Determination of the Resistance of Concrete to Abrasion and Impact by Ice Under Offshore and Arctic Conditions. Contractor report 1585 submitted by Arctec Canada Ltd to CANMET of the Department of Energy, Mines and Resources.

[5] Roots, T., Nawwar, A., and Malhotra, V.M., 1986, Development of a Test Method to Determine the Resistance of Concrete to Ice Abrasion and/or Impact. Proc. CSE/CANMET International Workshop on Concrete.

[6] Comfort, G., 1990, Results of Two Tests Conducted to Evaluate the Wear Resistance of Concrete to Ice Abrasion, Fleet Technology Report 3905 submitted to CANMET of the Department of Energy, Mines and Resources (in press).

APPENDIX A

RAW DATA: TEST #3

Note: See Comfort, 1989 a;b for an explanation of the format of the enclosed spreadsheets.

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9B

Concrete Mixture No.: 9

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 82.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	3.844	3.888	3.860	3.878	0.031	4.286	4.256	4.264	4.245	-0.031	3.771	3.900	3.895	3.776	0.08
Pt. 2	3.764	3.768	3.771	3.776	0.008	3.968	3.978	3.977	3.972	0.008	4.235	4.360	4.245	4.247	0.049
Pt. 3	3.435	3.548	3.580	3.560	0.128	4.637	4.684	4.651	4.660	0.028	3.700	4.043	4.029	4.014	0.329
Pt. 4	3.767	3.730	3.733	3.743	-0.032	3.764	3.804	3.800	3.800	0.037	3.794	3.816	3.777	3.788	0.000
Pt. 5	3.253	3.304	3.316	3.326	0.062	3.962	4.110	4.094	4.147	0.155	3.415	3.490	3.502	3.472	0.073
Pt. 6	3.169	3.265	3.275	3.271	0.101	4.194	4.206	4.191	4.094	-0.030	3.601	3.591	3.599	3.598	-0.005
Pt. 7	3.931	3.903	3.945	3.914	-0.010	3.525	3.603	3.563	3.588	0.060	3.093	3.135	3.102	3.118	0.025
Pt. 8	2.995	3.044	3.040	3.036	0.045	3.819	3.880	3.903	3.877	0.068	2.935	2.986	2.977	2.980	0.046
Pt. 9	3.049	3.115	3.098	3.113	0.060	3.674	3.699	3.720	3.700	0.032	3.902	3.912	3.944	3.955	0.035
Pt. 10	3.523	3.498	3.491	3.526	-0.018	3.453	3.479	3.464	3.465	0.016	3.304	3.317	3.346	3.332	0.028
2nd 0	-1.194	-1.187	-1.192	-1.190		-0.615	-0.611	-0.620	-0.600		-0.280	-0.293	-0.280	-0.270	
Profile Area (mm^2)	1274.96	1287.52	1289.50	1290.45		1445.95	1461.87	1459.17	1456.28		1315.73	1345.28	1340.02	1335.71	
Avg. Wear (mm) Over Profile		0.032	0.037	0.039	0.036		0.040	0.034	0.026	0.033		0.075	0.062	0.051	0.063

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9B

Concrete Mixture No.: 9

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 82.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	3.844	0.043	0.016	0.034	0.031	4.286	-0.030	-0.021	-0.043	-0.032	3.771	0.130	0.124	0.004	0.086
Pt. 2	3.764	0.003	0.007	0.011	0.007	3.968	0.009	0.010	0.001	0.007	4.235	0.128	0.010	0.010	0.049
Pt. 3	3.435	0.111	0.144	0.124	0.126	4.637	0.046	0.016	0.019	0.027	3.700	0.347	0.329	0.311	0.329
Pt. 4	3.767	-0.040	-0.035	-0.026	-0.033	3.764	0.038	0.038	0.030	0.036	3.794	0.027	-0.017	-0.010	0.000
Pt. 5	3.253	0.048	0.062	0.071	0.060	3.962	0.146	0.134	0.178	0.153	3.415	0.081	0.087	0.052	0.073
Pt. 6	3.169	0.092	0.105	0.100	0.099	4.194	0.010	0.000	-0.109	-0.033	3.601	-0.002	-0.002	-0.009	-0.004
Pt. 7	3.931	-0.033	0.013	-0.020	-0.013	3.525	0.075	0.041	0.053	0.057	3.093	0.051	0.009	0.018	0.026
Pt. 8	2.995	0.044	0.043	0.038	0.042	3.819	0.058	0.088	0.047	0.064	2.935	0.061	0.042	0.037	0.047
Pt. 9	3.049	0.060	0.047	0.061	0.056	3.674	0.022	0.050	0.013	0.028	3.902	0.021	0.042	0.044	0.036
Pt. 10	3.523	-0.032	-0.034	-0.001	-0.022	3.453	0.022	0.016	-0.002	0.012	3.304	0.025	0.042	0.019	0.029
2nd 0	-1.194					-0.615					-0.280				
Profile Area (mm^2)		11.198	14.155	14.713			15.134	14.191	7.400			32.085	24.287	18.027	
Avg. Wear (mm) Over Profile		0.028	0.036	0.037	0.034		0.039	0.036	0.019	0.031		0.082	0.062	0.046	0.063

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9B

Concrete Mixture No.: 9

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 113.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	3.844	3.862	3.872	3.867	0.023	4.286	4.353	4.352	4.343	0.063	3.771	3.944	3.962	3.958	0.184
Pt. 2	3.764	3.777	3.770	3.772	0.009	3.968	4.030	4.031	4.029	0.062	4.235	4.299	4.360	4.365	0.106
Pt. 3	3.435	3.558	3.564	3.545	0.121	4.637	4.615	4.604	4.605	-0.029	3.700	3.986	4.010	4.011	0.302
Pt. 4	3.767	3.724	3.742	3.733	-0.034	3.764	3.846	3.851	3.857	0.087	3.794	3.868	3.877	3.817	0.060
Pt. 5	3.253	3.304	3.304	3.299	0.049	3.962	4.123	4.099	4.106	0.147	3.415	3.522	3.531	3.528	0.112
Pt. 6	3.169	3.287	3.262	3.260	0.101	4.194	4.205	4.217	4.203	0.014	3.601	3.536	3.540	3.563	-0.055
Pt. 7	3.931	3.928	3.930	3.914	-0.007	3.525	3.626	3.620	3.624	0.098	3.093	3.188	3.193	3.157	0.086
Pt. 8	2.995	3.027	3.042	3.035	0.040	3.819	3.899	3.890	3.911	0.081	2.935	2.963	3.000	2.983	0.047
Pt. 9	3.049	3.111	3.144	3.125	0.078	3.674	3.737	3.744	3.748	0.069	3.902	4.093	4.047	4.008	0.147
Pt. 10	3.523	3.461	3.488	3.476	-0.048	3.453	3.550	3.536	3.539	0.089	3.304	3.318	3.333	3.318	0.019
2nd 0	-1.194	-1.178	-1.180	-1.184		-0.615	-0.620	-0.603	-0.610		-0.280	-0.288	-0.274	-0.296	
Profile Area (mm^2)	1274.96	1287.02	1289.79	1286.39		1445.95	1471.63	1470.20	1471.04		1315.73	1351.35	1356.32	1350.92	
Avg. Wear (mm) Over Profile		0.031	0.038	0.029	0.033		0.065	0.062	0.064	0.064		0.091	0.103	0.090	0.094

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9B

Concrete Mixture No.: 9

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 113.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	3.844	0.016	0.026	0.022	0.022	4.286	0.068	0.065	0.056	0.063	3.771	0.174	0.190	0.189	0.184
Pt. 2	3.764	0.010	0.003	0.006	0.006	3.968	0.063	0.061	0.060	0.061	4.235	0.066	0.124	0.133	0.108
Pt. 3	3.435	0.118	0.125	0.107	0.117	4.637	-0.020	-0.037	-0.033	-0.030	3.700	0.288	0.308	0.316	0.304
Pt. 4	3.767	-0.049	-0.030	-0.038	-0.039	3.764	0.084	0.082	0.091	0.086	3.794	0.077	0.081	0.029	0.062
Pt. 5	3.253	0.043	0.044	0.041	0.043	3.962	0.163	0.131	0.142	0.145	3.415	0.111	0.113	0.121	0.115
Pt. 6	3.169	0.109	0.085	0.085	0.093	4.194	0.014	0.016	0.006	0.012	3.601	-0.060	-0.064	-0.029	-0.051
Pt. 7	3.931	-0.014	-0.010	-0.024	-0.016	3.525	0.104	0.087	0.096	0.096	3.093	0.100	0.096	0.075	0.090
Pt. 8	2.995	0.020	0.036	0.032	0.030	3.819	0.084	0.062	0.088	0.078	2.935	0.034	0.060	0.060	0.052
Pt. 9	3.049	0.048	0.083	0.067	0.066	3.674	0.067	0.060	0.070	0.066	3.902	0.198	0.140	0.120	0.152
Pt. 10	3.523	-0.077	-0.048	-0.057	-0.061	3.453	0.102	0.072	0.081	0.085	3.304	0.022	0.023	0.029	0.025
2nd 0	-1.194					-0.615					-0.280				
Profile Area (mm^2)	8.941	12.099	9.485			26.647	21.906	24.111			37.178	39.413	38.303		
Avg. Wear (mm) Over Profile	0.023	0.031	0.024	0.026		0.068	0.056	0.061	0.062		0.095	0.100	0.097	0.097	

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9B

Concrete Mixture No.: 9

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 163.5

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt. 1	3.844	3.871	3.878	3.878	0.032	4.286	4.303	4.301	4.296	0.014	3.771	3.937	3.939	3.946	0.170
Pt. 2	3.764	3.816	3.792	3.797	0.038	3.968	3.944	3.904	3.942	-0.038	4.235	4.277	4.287	4.301	0.053
Pt. 3	3.435	3.579	3.587	3.590	0.150	4.637	4.663	4.724	4.742	0.073	3.700	4.098	4.091	4.096	0.395
Pt. 4	3.767	3.768	3.773	3.765	0.002	3.764	3.760	3.765	3.756	-0.004	3.794	3.883	3.917	3.871	0.096
Pt. 5	3.253	3.338	3.341	3.348	0.089	3.962	4.065	4.050	4.080	0.103	3.415	3.500	3.494	3.565	0.105
Pt. 6	3.169	3.312	3.303	3.308	0.139	4.194	4.242	4.261	4.254	0.058	3.601	3.638	3.656	3.655	0.049
Pt. 7	3.931	3.985	3.967	3.963	0.041	3.525	3.560	3.533	3.580	0.033	3.093	3.205	3.207	3.222	0.118
Pt. 8	2.995	3.079	3.081	3.074	0.083	3.819	3.961	3.960	3.940	0.135	2.935	3.028	3.016	3.013	0.084
Pt. 9	3.049	3.175	3.185	3.178	0.130	3.674	3.795	3.791	3.797	0.120	3.902	4.056	4.028	4.099	0.159
Pt. 10	3.523	3.512	3.514	3.511	-0.011	3.453	3.620	3.609	3.604	0.158	3.304	3.425	3.442	3.407	0.121
2nd 0	-1.194	-1.184	-1.186	-1.173		-0.615	-0.607	-0.603	-0.608		-0.280	-0.283	-0.279	-0.273	
Profile Area (mm^2)	1274.96	1301.71	1301.12	1300.80		1445.95	1468.79	1468.30	1471.91		1315.73	1353.27	1364.29	1368.21	
Avg. Wear (mm) Over Profile		0.068	0.067	0.066	0.067		0.058	0.057	0.066	0.060		0.121	0.124	0.134	0.126

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9B

Concrete Mixture No.: 9

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 163.5

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt. 1	3.844	0.026	0.033	0.032	0.030	4.286	0.016	0.014	0.009	0.013	3.771	0.166	0.168	0.174	0.169
Pt. 2	3.764	0.050	0.026	0.029	0.035	3.968	-0.026	-0.066	-0.027	-0.040	4.235	0.043	0.052	0.065	0.053
Pt. 3	3.435	0.141	0.150	0.149	0.146	4.637	0.024	0.083	0.103	0.070	3.700	0.399	0.391	0.394	0.395
Pt. 4	3.767	-0.003	0.003	-0.010	-0.003	3.764	-0.007	-0.004	-0.011	-0.007	3.794	0.090	0.123	0.074	0.096
Pt. 5	3.253	0.080	0.084	0.085	0.083	3.962	0.099	0.082	0.115	0.099	3.415	0.086	0.079	0.147	0.104
Pt. 6	3.169	0.137	0.129	0.127	0.131	4.194	0.043	0.060	0.056	0.053	3.601	0.039	0.054	0.050	0.048
Pt. 7	3.931	0.047	0.031	0.018	0.032	3.525	0.030	0.000	0.050	0.027	3.093	0.114	0.113	0.124	0.117
Pt. 8	2.995	0.076	0.080	0.063	0.073	3.819	0.136	0.132	0.116	0.128	2.935	0.095	0.080	0.073	0.083
Pt. 9	3.049	0.117	0.129	0.111	0.119	3.674	0.114	0.107	0.117	0.113	3.902	0.157	0.125	0.191	0.158
Pt. 10	3.523	-0.021	-0.017	-0.032	-0.023	3.453	0.159	0.145	0.144	0.149	3.304	0.124	0.137	0.096	0.119
2nd 0	-1.194					-0.615					-0.280				
Profile Area (mm^2)		24.806	24.603	21.745			21.276	20.010	24.593			48.121	48.359	51.107	
Avg. Wear (mm) Over Profile		0.063	0.063	0.055	0.060		0.054	0.051	0.063	0.056		0.122	0.123	0.130	0.125

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9A

Concrete Mixture No.: 9

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 82.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	3.554	3.623	3.642	3.627	0.077	3.361	4.295	4.307	4.283	0.934	3.860	3.909	3.890	3.895	0.038
Pt. 2	3.544	3.627	3.624	3.628	0.082	3.239	4.834	4.833	4.820	1.590	3.840	4.731	4.754	4.744	0.903
Pt. 3	3.523	3.592	3.591	3.596	0.070	3.152	3.260	3.266	3.257	0.109	3.918	4.457	4.462	4.451	0.539
Pt. 4	3.450	3.535	3.530	3.536	0.084	3.121	3.129	3.131	3.140	0.012	4.051	4.038	4.037	4.035	-0.014
Pt. 5	3.400	3.495	3.494	3.494	0.094	3.011	3.044	3.036	3.046	0.031	4.088	4.070	4.071	4.071	-0.017
Pt. 6	3.401	3.468	3.468	3.466	0.066	2.946	2.973	2.965	2.971	0.024	4.111	5.185	5.106	5.152	1.037
Pt. 7	3.326	3.393	3.385	3.309	0.036	2.862	2.888	2.867	2.866	0.012	4.112	4.149	4.151	4.151	0.038
Pt. 8	3.242	3.310	3.316	3.243	0.048	2.845	2.866	2.868	2.864	0.021	4.117	4.165	4.167	4.162	0.048
Pt. 9	3.261	3.339	3.344	3.342	0.081	2.797	2.782	2.810	2.818	0.006	4.285	4.764	4.790	4.769	0.489
Pt. 10	3.243	3.009	3.125	3.054	-0.180	2.623	2.660	2.635	2.652	0.026	4.213	4.296	4.298	4.289	0.081
2nd 0	-0.543	-0.545	-0.526	-0.514		-1.080	-1.055	-1.053	-1.051		-0.690	-0.710	-0.710	-0.670	
Profile Area (mm^2)	1248.75	1266.86	1270.85	1262.88		1102.17	1201.50	1201.09	1201.09		1493.79	1613.67	1612.33	1612.09	
Avg. Wear (mm) Over Profile		0.046	0.056	0.036	0.046		0.253	0.252	0.252	0.252		0.305	0.302	0.301	0.303

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9A

Concrete Mixture No.: 9

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 82.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	3.554	0.069	0.086	0.070	0.075	3.361	0.931	0.943	0.919	0.931	3.860	0.051	0.032	0.033	0.039
Pt. 2	3.544	0.083	0.077	0.078	0.079	3.239	1.590	1.589	1.575	1.585	3.840	0.895	0.918	0.900	0.904
Pt. 3	3.523	0.070	0.063	0.064	0.066	3.152	0.101	0.106	0.096	0.101	3.918	0.545	0.550	0.527	0.541
Pt. 4	3.450	0.086	0.073	0.075	0.078	3.121	-0.002	-0.001	0.008	0.002	4.051	-0.005	-0.006	-0.024	-0.012
Pt. 5	3.400	0.096	0.086	0.080	0.087	3.011	0.021	0.012	0.021	0.018	4.088	-0.008	-0.007	-0.027	-0.014
Pt. 6	3.401	0.068	0.057	0.048	0.058	2.946	0.013	0.003	0.008	0.008	4.111	1.086	1.007	1.029	1.041
Pt. 7	3.326	0.068	0.048	-0.036	0.027	2.862	0.009	-0.013	-0.015	-0.006	4.112	0.050	0.052	0.026	0.043
Pt. 8	3.242	0.070	0.061	-0.021	0.037	2.845	0.002	0.002	-0.003	0.000	4.117	0.063	0.065	0.030	0.053
Pt. 9	3.261	0.080	0.068	0.056	0.068	2.797	-0.037	-0.010	-0.004	-0.017	4.285	0.496	0.522	0.467	0.495
Pt. 10	3.243	-0.232	-0.134	-0.217	-0.194	2.623	0.013	-0.014	0.001	0.000	4.213	0.102	0.104	0.057	0.088
2nd 0	-0.543					-1.080					-0.690				
Profile Area (mm^2)		18.501	18.789	8.478			94.455	93.655	93.272			123.774	122.438	114.398	
Avg. Wear (mm) Over Profile		0.047	0.048	0.022	0.039		0.240	0.238	0.237	0.239		0.315	0.312	0.291	0.306

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9A

Concrete Mixture No.: 9

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 113.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	3.554	3.622	3.614	3.617	0.064	3.361	4.241	4.216	4.264	0.879	3.860	3.976	3.957	3.960	0.104
Pt. 2	3.544	3.653	3.650	3.648	0.106	3.239	4.872	4.861	4.839	1.618	3.840	4.388	4.317	4.323	0.503
Pt. 3	3.523	3.613	3.615	3.613	0.091	3.152	4.686	4.669	4.675	1.525	3.918	4.596	4.589	4.603	0.678
Pt. 4	3.450	3.567	3.565	3.564	0.115	3.121	3.177	3.166	3.156	0.045	4.051	4.103	4.097	4.095	0.047
Pt. 5	3.400	3.525	3.520	3.503	0.116	3.011	3.063	3.057	3.042	0.043	4.088	4.046	4.042	4.048	-0.043
Pt. 6	3.401	3.505	3.505	3.501	0.103	2.946	3.000	2.989	2.983	0.045	4.111	5.244	5.262	5.260	1.144
Pt. 7	3.326	3.400	3.395	3.395	0.071	2.862	2.902	2.895	2.880	0.030	4.112	4.674	4.675	4.695	0.569
Pt. 8	3.242	3.328	3.325	3.326	0.084	2.845	2.884	2.870	2.855	0.025	4.117	4.023	4.029	4.033	-0.089
Pt. 9	3.261	3.317	3.372	3.371	0.092	2.797	2.824	2.817	2.807	0.019	4.285	4.757	4.760	4.756	0.473
Pt. 10	3.243	3.288	3.292	3.271	0.041	2.623	2.674	2.670	2.650	0.042	4.213	4.365	4.357	4.351	0.145
2nd 0	-0.543	-0.531	-0.538	-0.541		-1.080	-1.064	-1.072	-1.082		-0.690	-0.696	-0.667	-0.683	
Profile Area (mm^2)	1248.75	1281.31	1282.67	1281.11		1102.17	1262.41	1258.30	1255.87		1493.79	1628.32	1625.18	1626.69	
Avg. Wear (mm) Over Profile		0.083	0.086	0.082	0.084		0.408	0.397	0.391	0.399		0.342	0.334	0.338	0.338

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9A

Concrete Mixture No.: 9

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 113.6

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	3.554	0.067	0.059	0.063	0.063	3.361	0.878	0.854	0.903	0.879	3.860	0.117	0.094	0.099	0.103
Pt. 2	3.544	0.107	0.105	0.104	0.105	3.239	1.630	1.620	1.600	1.617	3.840	0.549	0.472	0.482	0.501
Pt. 3	3.523	0.086	0.091	0.089	0.089	3.152	1.529	1.515	1.524	1.522	3.918	0.680	0.664	0.683	0.676
Pt. 4	3.450	0.112	0.113	0.113	0.113	3.121	0.050	0.042	0.036	0.042	4.051	0.054	0.037	0.041	0.044
Pt. 5	3.400	0.119	0.118	0.102	0.113	3.011	0.044	0.042	0.032	0.039	4.088	-0.039	-0.057	-0.043	-0.047
Pt. 6	3.401	0.097	0.101	0.099	0.099	2.946	0.045	0.038	0.038	0.040	4.111	1.136	1.138	1.145	1.140
Pt. 7	3.326	0.066	0.066	0.068	0.066	2.862	0.029	0.028	0.019	0.025	4.112	0.566	0.548	0.578	0.564
Pt. 8	3.242	0.077	0.079	0.082	0.080	2.845	0.027	0.019	0.012	0.019	4.117	-0.089	-0.105	-0.089	-0.095
Pt. 9	3.261	0.046	0.107	0.108	0.087	2.797	0.013	0.013	0.012	0.013	4.285	0.477	0.455	0.465	0.466
Pt. 10	3.243	0.034	0.044	0.026	0.035	2.623	0.036	0.039	0.029	0.035	4.213	0.158	0.122	0.131	0.137
2nd 0	-0.543					-1.080					-0.690				
Profile Area (mm^2)		30.219	32.944	31.970			157.127	154.571	154.090			135.698	126.906	131.531	
Avg. Wear (mm) Over Profile		0.077	0.084	0.081	0.081		0.400	0.393	0.392	0.395		0.345	0.323	0.335	0.334

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9A

Concrete Mixture No.: 9

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 163.5

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt. 1	3.554	3.607	3.618	3.616	0.060	3.361	4.338	4.429	4.468	1.051	3.860	4.000	4.002	4.002	0.141
Pt. 2	3.544	3.644	3.643	3.644	0.100	3.239	4.823	4.857	4.863	1.609	3.840	5.524	5.522	5.506	1.677
Pt. 3	3.523	3.624	3.582	3.608	0.082	3.152	4.487	4.497	4.481	1.336	3.918	4.777	4.746	4.704	0.824
Pt. 4	3.450	3.597	3.554	3.557	0.119	3.121	3.188	3.207	3.207	0.080	4.051	4.676	4.717	4.674	0.638
Pt. 5	3.400	3.509	3.508	3.492	0.103	3.011	3.092	3.103	3.099	0.087	4.088	4.551	4.508	4.526	0.440
Pt. 6	3.401	3.583	3.496	3.512	0.129	2.946	3.028	3.038	3.035	0.088	4.111	5.408	5.322	5.435	1.277
Pt. 7	3.326	3.436	3.426	3.416	0.100	2.862	2.900	2.928	2.913	0.052	4.112	4.992	4.984	4.976	0.872
Pt. 8	3.242	3.447	3.323	3.312	0.119	2.845	2.898	2.883	2.885	0.044	4.117	5.167	5.170	5.186	1.057
Pt. 9	3.261	3.763	3.770	3.775	0.508	2.797	2.841	2.848	2.832	0.043	4.285	4.957	4.866	4.964	0.644
Pt. 10	3.243	3.339	3.362	3.364	0.112	2.623	2.704	2.724	2.703	0.087	4.213	5.043	5.047	5.041	0.831
2nd 0	-0.543	-0.524	-0.517	-0.548		-1.080	-1.066	-1.078	-1.079		-0.690	-0.672	-0.688	-0.683	
Profile Area (mm^2)	1248.75	1308.92	1298.53	1299.06		1102.17	1260.67	1268.13	1266.95		1493.79	1811.29	1803.21	1808.20	
Avg. Wear (mm) Over Profile		0.153	0.127	0.128	0.136		0.403	0.422	0.419	0.415		0.808	0.787	0.800	0.798

Concrete Abrasion Tests - Wear Measurements

Test Number: 3

Concrete Sample: 9A

Concrete Mixture No.: 9

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 163.5

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt. 1	3.554	0.051	0.061	0.063	0.058	3.361	0.975	1.068	1.107	1.050	3.860	0.138	0.142	0.141	0.140
Pt. 2	3.544	0.096	0.094	0.101	0.097	3.239	1.581	1.618	1.624	1.608	3.840	1.680	1.682	1.665	1.676
Pt. 3	3.523	0.095	0.051	0.087	0.078	3.152	1.331	1.344	1.329	1.335	3.918	0.854	0.827	0.784	0.822
Pt. 4	3.450	0.140	0.094	0.109	0.114	3.121	0.062	0.085	0.086	0.077	4.051	0.618	0.665	0.620	0.634
Pt. 5	3.400	0.100	0.096	0.094	0.097	3.011	0.074	0.091	0.088	0.084	4.088	0.454	0.419	0.435	0.436
Pt. 6	3.401	0.171	0.080	0.114	0.122	2.946	0.074	0.091	0.088	0.084	4.111	1.287	1.210	1.320	1.272
Pt. 7	3.326	0.097	0.083	0.093	0.091	2.862	0.029	0.065	0.050	0.048	4.112	0.868	0.871	0.859	0.866
Pt. 8	3.242	0.191	0.061	0.074	0.109	2.845	0.042	0.036	0.039	0.039	4.117	1.036	1.051	1.064	1.050
Pt. 9	3.261	0.486	0.487	0.518	0.497	2.797	0.032	0.049	0.034	0.038	4.285	0.657	0.579	0.673	0.636
Pt. 10	3.243	0.078	0.094	0.126	0.099	2.623	0.068	0.099	0.079	0.082	4.213	0.813	0.832	0.821	0.822
2nd 0	-0.543					-1.080					-0.690				
Profile Area (mm^2)		56.470	44.709	51.287			155.770	165.575	164.585			313.987	309.028	313.045	
Avg. Wear (mm) Over Profile		0.144	0.114	0.131	0.129		0.396	0.421	0.419	0.412		0.799	0.786	0.797	0.794

APPENDIX B

RAW DATA: TEST #4

Note: See Comfort, 1989 a;b for an explanation of the format of the enclosed spreadsheets.

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8A

Concrete Mixture No.: 8

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 70.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	2.900	3.046	3.043	3.036	0.142	3.172	3.180	3.180	3.188	0.011	2.882	3.239	3.255	3.253	0.367
Pt. 2	2.827	2.973	2.969	2.973	0.145	3.140	3.146	3.145	3.156	0.009	2.914	2.912	2.909	2.905	-0.005
Pt. 3	2.777	2.909	2.910	2.898	0.129	3.056	3.069	3.064	3.065	0.010	2.891	2.864	2.880	2.889	-0.013
Pt. 4	2.640	2.904	2.939	2.938	0.287	2.836	4.386	4.389	4.388	1.552	2.869	2.876	2.892	2.877	0.013
Pt. 5	2.685	2.802	2.806	2.793	0.115	2.692	2.756	2.745	2.740	0.055	2.912	2.905	2.929	2.904	0.001
Pt. 6	2.726	2.833	2.839	2.833	0.109	2.723	2.735	2.730	2.732	0.009	2.940	2.915	2.919	2.941	-0.015
Pt. 7	2.625	2.740	2.730	2.720	0.105	2.611	2.625	2.630	2.632	0.018	2.911	2.916	2.925	2.930	0.013
Pt. 8	2.707	2.773	2.769	2.751	0.057	2.567	2.582	2.572	2.578	0.010	2.706	2.726	2.696	2.717	0.007
Pt. 9	2.537	2.633	2.630	2.613	0.088	2.445	2.432	2.448	2.447	-0.003	2.667	2.681	2.685	2.674	0.013
Pt. 10	2.366	2.462	2.464	2.454	0.094	2.337	2.334	2.344	2.345	0.004	2.839	2.839	2.848	2.814	-0.005
2nd 0	-0.685	-0.678	-0.667	-0.690		-0.772	-0.771	-0.766	-0.790		-0.355	-0.344	-0.352	-0.354	
Profile Area (mm^2)	0986.21	1033.58	1034.50	1031.18		1014.68	1078.12	1078.13	1078.98		1049.56	1060.25	1062.56	1061.50	
Avg. Wear (mm) Over Profile		0.121	0.123	0.114	0.119		0.161	0.161	0.164	0.162		0.027	0.033	0.030	0.030

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8A

Concrete Mixture No.: 8

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 70.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	2.900	0.145	0.141	0.137	0.141	3.172	0.008	0.007	0.018	0.011	2.882	0.356	0.373	0.371	0.366
Pt. 2	2.827	0.145	0.138	0.147	0.143	3.140	0.006	0.004	0.020	0.010	2.914	-0.004	-0.006	-0.009	-0.006
Pt. 3	2.777	0.130	0.128	0.123	0.127	3.056	0.013	0.006	0.014	0.011	2.891	-0.030	-0.012	-0.002	-0.015
Pt. 4	2.640	0.261	0.292	0.300	0.284	2.836	1.550	1.551	1.559	1.553	2.869	0.003	0.022	0.008	0.011
Pt. 5	2.685	0.114	0.112	0.110	0.112	2.692	0.064	0.050	0.057	0.057	2.912	-0.012	0.016	-0.008	-0.002
Pt. 6	2.726	0.103	0.103	0.110	0.105	2.723	0.011	0.004	0.019	0.011	2.940	-0.031	-0.023	0.000	-0.018
Pt. 7	2.625	0.110	0.093	0.098	0.101	2.611	0.013	0.015	0.033	0.020	2.911	-0.002	0.012	0.018	0.009
Pt. 8	2.707	0.061	0.048	0.048	0.052	2.567	0.014	0.000	0.025	0.013	2.706	0.012	-0.012	0.010	0.003
Pt. 9	2.537	0.090	0.078	0.080	0.083	2.445	-0.014	-0.002	0.017	0.000	2.667	0.005	0.015	0.006	0.009
Pt. 10	2.366	0.089	0.081	0.093	0.088	2.337	-0.004	0.001	0.025	0.007	2.839	-0.010	0.006	-0.026	-0.010
2nd 0	-0.685					-0.772					-0.355				
Profile Area (mm^2)		46.008	44.785	45.952			63.247	62.283	67.818			8.547	12.420	11.750	
Avg. Wear (mm) Over Profile		0.117	0.114	0.117	0.116		0.161	0.158	0.173	0.164		0.022	0.032	0.030	0.028

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8A

Concrete Mixture No.: 8

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 115.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	2.900	3.080	3.072	3.070	0.174	3.172	3.187	3.207	3.191	0.023	2.882	3.304	3.370	3.340	0.456
Pt. 2	2.827	3.006	2.998	2.996	0.173	3.140	3.154	3.163	3.165	0.021	2.914	2.914	2.922	2.930	0.008
Pt. 3	2.777	2.940	2.928	2.927	0.155	3.056	3.076	3.074	3.073	0.018	2.891	2.879	2.921	2.910	0.012
Pt. 4	2.640	2.984	2.983	3.004	0.350	2.836	4.372	4.389	4.404	1.552	2.869	2.892	2.896	2.893	0.025
Pt. 5	2.685	2.831	2.827	2.823	0.142	2.692	2.755	2.757	2.765	0.067	2.912	2.937	2.931	2.934	0.022
Pt. 6	2.726	2.860	2.854	2.854	0.130	2.723	2.740	2.744	2.743	0.019	2.940	2.932	2.936	2.931	-0.007
Pt. 7	2.625	2.754	2.748	2.747	0.125	2.611	2.636	2.638	2.639	0.027	2.911	2.923	2.942	2.938	0.023
Pt. 8	2.707	2.783	2.779	2.775	0.072	2.567	2.587	2.589	2.609	0.028	2.706	2.726	2.718	2.716	0.014
Pt. 9	2.537	2.651	2.641	2.636	0.106	2.445	2.465	2.462	2.460	0.017	2.667	2.689	2.709	2.714	0.037
Pt. 10	2.366	2.487	2.482	2.482	0.118	2.337	2.351	2.347	2.349	0.012	2.839	2.850	2.844	2.844	0.007
2nd 0	-0.685	-0.67	-0.685	-0.679		-0.772	-0.767	-0.781	-0.773		-0.355	-0.347	-0.349	-0.354	
Profile Area (mm^2)	0986.21	1044.66	1042.31	1042.40		1014.68	1080.93	1082.62	1083.78		1049.56	1066.34	1071.40	1070.11	
Avg. Wear (mm) Over Profile		0.149	0.143	0.143	0.145		0.169	0.173	0.176	0.172		0.043	0.056	0.052	0.050

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8A

Concrete Mixture No.: 8

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 115.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	2.900	0.178	0.172	0.169	0.173	3.172	0.014	0.036	0.019	0.023	2.882	0.421	0.487	0.458	0.455
Pt. 2	2.827	0.176	0.171	0.168	0.172	3.140	0.013	0.025	0.025	0.021	2.914	-0.002	0.007	0.016	0.007
Pt. 3	2.777	0.159	0.151	0.148	0.153	3.056	0.019	0.021	0.017	0.019	2.891	-0.014	0.028	0.019	0.011
Pt. 4	2.640	0.338	0.343	0.362	0.348	2.836	1.534	1.557	1.568	1.553	2.869	0.020	0.025	0.024	0.023
Pt. 5	2.685	0.139	0.142	0.135	0.139	2.692	0.061	0.069	0.073	0.068	2.912	0.021	0.016	0.022	0.020
Pt. 6	2.726	0.125	0.128	0.125	0.126	2.723	0.014	0.026	0.021	0.020	2.940	-0.013	-0.007	-0.010	-0.010
Pt. 7	2.625	0.119	0.123	0.118	0.120	2.611	0.022	0.033	0.029	0.028	2.911	0.007	0.027	0.026	0.020
Pt. 8	2.707	0.065	0.072	0.063	0.067	2.567	0.016	0.029	0.043	0.029	2.706	0.014	0.007	0.009	0.010
Pt. 9	2.537	0.101	0.104	0.094	0.100	2.445	0.016	0.025	0.016	0.019	2.667	0.015	0.037	0.046	0.033
Pt. 10	2.366	0.107	0.116	0.110	0.111	2.337	0.009	0.019	0.013	0.014	2.839	0.003	-0.001	0.004	0.002
2nd 0	-0.685					-0.772					-0.355				
Profile Area (mm^2)		55.530	56.102	55.021			65.282	69.697	69.296			15.225	20.671	20.356	
Avg. Wear (mm) Over Profile		0.141	0.143	0.140	0.141		0.166	0.177	0.176	0.173		0.039	0.053	0.052	0.048

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8A

Concrete Mixture No.: 8

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 145.9

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	2.900	3.116	3.117	3.118	0.217	3.172	3.088	3.085	3.109	-0.078	2.882	3.123	3.139	3.130	0.249
Pt. 2	2.827	3.033	3.040	3.035	0.209	3.140	3.077	3.072	3.085	-0.062	2.914	4.315	4.300	4.310	1.394
Pt. 3	2.777	2.964	2.971	2.968	0.191	3.056	3.016	3.010	3.017	-0.042	2.891	3.770	3.763	3.767	0.876
Pt. 4	2.640	3.392	3.330	3.342	0.715	2.836	4.349	4.376	4.372	1.530	2.869	3.419	3.413	3.421	0.549
Pt. 5	2.685	5.067	5.070	5.074	2.385	2.692	4.001	4.014	4.013	1.317	2.912	3.014	2.992	3.000	0.090
Pt. 6	2.726	3.688	3.690	3.701	0.967	2.723	2.767	2.782	2.779	0.053	2.940	3.058	3.045	3.020	0.101
Pt. 7	2.625	3.110	3.036	3.085	0.452	2.611	3.343	3.357	3.439	0.769	2.911	2.986	3.004	3.002	0.086
Pt. 8	2.707	3.424	3.465	3.459	0.742	2.567	2.630	2.642	2.651	0.074	2.706	2.785	2.794	2.810	0.090
Pt. 9	2.537	3.415	3.414	3.446	0.888	2.445	2.902	2.915	2.919	0.467	2.667	2.791	2.792	2.789	0.124
Pt. 10	2.366	3.066	3.154	3.146	0.756	2.337	2.443	2.440	2.455	0.109	2.839	2.885	2.899	2.404	-0.110
2nd 0	-0.685	-0.67	-0.674	-0.681		-0.772	-0.671	-0.680	-0.670		-0.355	-0.346	-0.351	-0.353	
Profile Area (mm^2)	0986.21	1265.39	1265.26	1268.62		1014.68	1168.34	1171.31	1176.62		1049.56	1185.41	1185.02	1169.73	
Avg. Wear (mm) Over Profile		0.710	0.710	0.719	0.713		0.391	0.399	0.412	0.401		0.346	0.345	0.306	0.332

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8A

Concrete Mixture No.: 8

Concrete Surface: Smooth

Test Type: Abrasion

Cumulative Hours of Abrasion: 145.9

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	2.900	0.214	0.216	0.218	0.216	3.172	-0.095	-0.097	-0.074	-0.089	2.882	0.240	0.257	0.248	0.248
Pt. 2	2.827	0.203	0.211	0.207	0.207	3.140	-0.083	-0.086	-0.075	-0.082	2.914	1.399	1.385	1.396	1.393
Pt. 3	2.777	0.183	0.191	0.190	0.188	3.056	-0.070	-0.074	-0.070	-0.071	2.891	0.876	0.871	0.875	0.874
Pt. 4	2.640	0.746	0.686	0.700	0.711	2.836	1.474	1.504	1.496	1.491	2.869	0.546	0.542	0.551	0.547
Pt. 5	2.685	2.375	2.380	2.387	2.381	2.692	1.261	1.278	1.272	1.270	2.912	0.098	0.078	0.087	0.088
Pt. 6	2.726	0.953	0.958	0.973	0.961	2.723	-0.015	0.006	-0.003	-0.004	2.940	0.113	0.103	0.079	0.098
Pt. 7	2.625	0.475	0.404	0.457	0.445	2.611	0.664	0.684	0.760	0.703	2.911	0.069	0.090	0.090	0.083
Pt. 8	2.707	0.706	0.750	0.749	0.735	2.567	-0.014	0.005	0.006	-0.001	2.706	0.072	0.085	0.102	0.087
Pt. 9	2.537	0.865	0.868	0.906	0.879	2.445	0.370	0.391	0.386	0.382	2.667	0.116	0.122	0.120	0.119
Pt. 10	2.366	0.686	0.778	0.776	0.747	2.337	0.010	0.016	0.021	0.016	2.839	0.037	0.056	-0.437	-0.114
2nd 0	-0.685					-0.772					-0.355				
Profile Area (mm^2)		276.254	276.908	281.634			133.972	138.700	142.057			134.097	134.685	119.783	
Avg. Wear (mm) Over Profile		0.703	0.705	0.717	0.708		0.341	0.353	0.361	0.352		0.341	0.343	0.305	0.330

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8B

Concrete Mixture No.: 8

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 70.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	2.740	2.929	2.924	2.908	0.180	3.760	3.787	3.780	3.782	0.023	3.958	4.068	4.146	4.053	0.131
Pt. 2	2.794	3.027	2.989	3.005	0.213	4.103	4.132	4.153	4.103	0.026	3.117	3.428	3.437	3.466	0.327
Pt. 3	3.034	3.168	3.187	3.098	0.117	3.317	3.374	3.359	3.365	0.049	2.793	3.100	3.100	3.109	0.310
Pt. 4	2.393	2.582	2.600	2.568	0.190	3.771	3.793	3.797	3.789	0.022	3.433	3.810	3.764	3.760	0.345
Pt. 5	2.770	2.976	3.000	2.963	0.210	3.704	3.737	3.734	3.744	0.034	2.605	2.874	2.888	2.885	0.277
Pt. 6	2.659	2.768	2.741	2.710	0.081	3.524	3.540	3.533	3.536	0.012	2.727	2.950	2.976	2.920	0.222
Pt. 7	2.260	2.433	2.450	2.438	0.180	3.367	3.390	3.406	3.398	0.031	2.955	3.332	3.339	3.310	0.372
Pt. 8	2.238	2.420	2.439	2.425	0.190	3.517	3.585	3.558	3.585	0.059	2.670	2.924	2.916	2.932	0.254
Pt. 9	2.427	2.550	2.500	2.507	0.092	3.639	3.660	3.669	3.670	0.027	3.155	3.367	3.424	3.442	0.256
Pt. 10	2.493	2.624	2.631	2.603	0.126	3.161	3.206	3.215	3.207	0.048	3.175	3.460	3.477	3.488	0.300
2nd 0	-0.955	-0.937	-0.949	-0.930		-0.834	-0.842	-0.831	-0.842		-0.370	-0.350	-0.351	-0.375	
Profile Area (mm^2)	0949.01	1010.50	1009.88	1001.18		1321.05	1333.57	1333.56	1332.64		1118.68	1219.92	1225.16	1221.81	
Avg. Wear (mm) Over Profile		0.156	0.155	0.133	0.148		0.032	0.032	0.030	0.031		0.258	0.271	0.262	0.264

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8B

Concrete Mixture No.: 8

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 70.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	2.740	0.187	0.183	0.165	0.179	3.760	0.028	0.020	0.023	0.023	3.958	0.108	0.186	0.096	0.130
Pt. 2	2.794	0.229	0.194	0.206	0.210	4.103	0.031	0.049	0.002	0.027	3.117	0.307	0.316	0.350	0.324
Pt. 3	3.034	0.129	0.151	0.057	0.112	3.317	0.059	0.041	0.050	0.050	2.793	0.301	0.301	0.318	0.307
Pt. 4	2.393	0.182	0.205	0.165	0.184	3.771	0.025	0.025	0.021	0.024	3.433	0.369	0.324	0.329	0.341
Pt. 5	2.770	0.197	0.227	0.181	0.202	3.704	0.037	0.029	0.044	0.036	2.605	0.259	0.274	0.282	0.272
Pt. 6	2.659	0.099	0.079	0.037	0.071	3.524	0.021	0.007	0.017	0.015	2.727	0.211	0.238	0.196	0.215
Pt. 7	2.260	0.161	0.186	0.161	0.169	3.367	0.028	0.037	0.036	0.034	2.955	0.364	0.371	0.358	0.364
Pt. 8	2.238	0.168	0.196	0.168	0.178	3.517	0.074	0.039	0.074	0.062	2.670	0.239	0.232	0.266	0.245
Pt. 9	2.427	0.108	0.068	0.059	0.078	3.639	0.028	0.027	0.038	0.031	3.155	0.195	0.253	0.291	0.246
Pt. 10	2.493	0.114	0.132	0.086	0.111	3.161	0.053	0.051	0.054	0.052	3.175	0.266	0.284	0.318	0.289
2nd 0	-0.955					-0.834					-0.370				
Profile Area (mm^2)	57.983	59.700	47.292			14.080	11.922	13.154			97.336	102.776	104.106		
Avg. Wear (mm) Over Profile	0.148	0.152	0.120	0.140		0.036	0.030	0.033	0.033		0.248	0.262	0.265	0.258	

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8B

Concrete Mixture No.: 8

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 115.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	2.740	2.945	2.937	2.945	0.202	3.760	3.796	3.798	3.806	0.040	3.958	4.070	4.082	4.108	0.129
Pt. 2	2.794	3.014	3.016	3.021	0.223	4.103	4.134	4.142	4.147	0.038	3.117	3.438	3.448	3.468	0.334
Pt. 3	3.034	3.200	3.140	3.150	0.129	3.317	3.367	3.388	3.377	0.060	2.793	3.114	3.125	3.115	0.325
Pt. 4	2.393	2.602	2.600	2.596	0.206	3.771	3.807	3.809	3.809	0.037	3.433	3.760	3.769	3.740	0.323
Pt. 5	2.770	2.990	3.007	2.995	0.227	3.704	3.749	3.754	3.746	0.046	2.605	2.890	2.902	2.903	0.293
Pt. 6	2.659	2.790	2.786	2.748	0.116	3.524	3.566	3.565	3.546	0.035	2.727	2.944	2.993	2.995	0.250
Pt. 7	2.260	2.454	2.485	2.471	0.210	3.367	3.403	3.409	3.416	0.042	2.955	3.304	3.310	3.345	0.365
Pt. 8	2.238	2.447	2.466	2.459	0.219	3.517	3.592	3.580	3.599	0.073	2.670	2.929	2.928	2.930	0.259
Pt. 9	2.427	2.546	2.562	2.555	0.127	3.639	3.687	3.674	3.672	0.039	3.155	3.441	3.443	3.447	0.289
Pt. 10	2.493	2.636	2.651	2.646	0.151	3.161	3.223	3.237	3.228	0.068	3.175	3.470	3.488	3.487	0.307
2nd 0	-0.955	-0.947	-0.949	-0.953		-0.834	-0.842	-0.835	-0.845		-0.370	-0.366	-0.363	-0.366	
Profile Area (mm^2)	0949.01	1015.92	1016.86	1014.41		1321.05	1337.97	1339.08	1338.71		1118.68	1221.63	1226.31	1228.05	
Avg. Wear (mm) Over Profile		0.170	0.173	0.166	0.170		0.043	0.046	0.045	0.045		0.262	0.274	0.278	0.271

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8B

Concrete Mixture No.: 8

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 115.3

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	2.740	0.204	0.196	0.205	0.202	3.760	0.037	0.038	0.047	0.041	3.958	0.112	0.123	0.150	0.128
Pt. 2	2.794	0.218	0.221	0.227	0.222	4.103	0.033	0.039	0.046	0.039	3.117	0.320	0.330	0.350	0.333
Pt. 3	3.034	0.164	0.104	0.115	0.128	3.317	0.052	0.071	0.063	0.062	2.793	0.320	0.330	0.321	0.324
Pt. 4	2.393	0.206	0.205	0.202	0.204	3.771	0.039	0.038	0.042	0.040	3.433	0.325	0.333	0.305	0.321
Pt. 5	2.770	0.216	0.234	0.224	0.225	3.704	0.049	0.050	0.047	0.049	2.605	0.283	0.294	0.296	0.291
Pt. 6	2.659	0.126	0.124	0.088	0.113	3.524	0.047	0.042	0.028	0.039	2.727	0.215	0.262	0.266	0.247
Pt. 7	2.260	0.189	0.221	0.210	0.206	3.367	0.041	0.043	0.056	0.047	2.955	0.346	0.350	0.387	0.361
Pt. 8	2.238	0.203	0.223	0.219	0.215	3.517	0.081	0.064	0.090	0.078	2.670	0.256	0.253	0.257	0.255
Pt. 9	2.427	0.112	0.130	0.126	0.123	3.639	0.055	0.036	0.042	0.044	3.155	0.283	0.282	0.289	0.284
Pt. 10	2.493	0.135	0.152	0.151	0.146	3.161	0.070	0.077	0.077	0.075	3.175	0.291	0.306	0.308	0.302
2nd 0	-0.955					-0.834					-0.370				
Profile Area (mm^2)		65.350	66.685	65.007			18.482	18.232	19.807			102.167	106.263	108.589	
Avg. Wear (mm) Over Profile		0.166	0.170	0.165	0.167		0.047	0.046	0.050	0.048		0.260	0.270	0.276	0.269

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: 8B

Concrete Mixture No.: 8

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 145.9

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Profile Depth (mm)	Avg. Pt. Wear (mm)
Pt.1	2.740	2.979	2.971	2.970	0.233	3.760	3.806	3.811	3.805	0.047	3.958	4.184	4.168	4.173	0.217
Pt. 2	2.794	3.092	3.071	3.074	0.285	4.103	4.157	4.150	4.153	0.050	3.117	3.504	3.525	3.536	0.405
Pt. 3	3.034	3.250	3.264	3.232	0.215	3.317	3.386	3.395	3.395	0.075	2.793	3.209	3.228	3.224	0.427
Pt. 4	2.393	2.655	2.646	2.645	0.256	3.771	3.847	3.833	3.835	0.067	3.433	3.863	3.817	3.850	0.410
Pt. 5	2.770	3.080	3.086	3.060	0.305	3.704	3.775	3.760	3.760	0.061	2.605	3.013	3.012	3.014	0.408
Pt. 6	2.659	2.881	2.873	2.862	0.213	3.524	3.577	3.578	3.560	0.048	2.727	3.102	3.116	3.109	0.382
Pt. 7	2.260	2.547	2.548	2.551	0.289	3.367	3.415	3.427	3.420	0.054	2.955	3.455	3.468	3.477	0.512
Pt. 8	2.238	2.777	2.783	2.781	0.542	3.517	3.624	3.611	3.611	0.098	2.670	3.031	3.041	3.041	0.368
Pt. 9	2.427	2.623	2.648	2.656	0.215	3.639	3.698	3.696	3.688	0.055	3.155	3.576	3.568	3.576	0.418
Pt. 10	2.493	2.710	2.747	2.751	0.243	3.161	3.241	3.232	3.245	0.078	3.175	3.585	3.632	3.640	0.444
2nd 0	-0.955	-0.956	-0.943	-0.952		-0.834	-0.836	-0.843	-0.843		-0.370	-0.369	-0.367	-0.374	
Profile Area (mm^2)	0949.01	1052.17	1053.62	1051.50		1321.05	1345.48	1344.25	1343.41		1118.68	1264.40	1266.22	1268.61	
Avg. Wear (mm) Over Profile		0.262	0.266	0.261	0.263		0.062	0.059	0.057	0.059		0.371	0.375	0.381	0.376

Concrete Abrasion Tests - Wear Measurements

Test Number: 4

Concrete Sample: BB

Concrete Mixture No.: 8

Concrete Surface: Textured

Test Type: Abrasion

Cumulative Hours of Abrasion: 145.9

Cumulative No. of Impacts: 0

	Location 1					Location 2					Location 3				
	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)	Profile Ref. Depth (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Corrected Wear (mm)	Avg. Pt. Wear (mm)
Pt.1	2.740	0.239	0.230	0.230	0.233	3.760	0.046	0.052	0.046	0.048	3.958	0.226	0.210	0.215	0.217
Pt. 2	2.794	0.298	0.275	0.279	0.284	4.103	0.054	0.049	0.052	0.052	3.117	0.387	0.407	0.420	0.405
Pt. 3	3.034	0.216	0.226	0.197	0.213	3.317	0.070	0.081	0.081	0.077	2.793	0.416	0.434	0.432	0.427
Pt. 4	2.393	0.262	0.248	0.251	0.254	3.771	0.077	0.066	0.068	0.070	3.433	0.430	0.383	0.419	0.410
Pt. 5	2.770	0.310	0.310	0.289	0.303	3.704	0.072	0.060	0.060	0.064	2.605	0.408	0.406	0.411	0.408
Pt. 6	2.659	0.223	0.207	0.201	0.210	3.524	0.054	0.059	0.041	0.052	2.727	0.374	0.387	0.384	0.382
Pt. 7	2.260	0.288	0.280	0.289	0.286	3.367	0.049	0.066	0.059	0.058	2.955	0.499	0.511	0.525	0.512
Pt. 8	2.238	0.540	0.536	0.541	0.539	3.517	0.109	0.101	0.101	0.103	2.670	0.360	0.369	0.374	0.368
Pt. 9	2.427	0.197	0.211	0.226	0.211	3.639	0.061	0.065	0.057	0.061	3.155	0.420	0.410	0.424	0.418
Pt. 10	2.493	0.218	0.243	0.255	0.239	3.161	0.082	0.080	0.093	0.085	3.175	0.409	0.454	0.469	0.444
2nd 0	-0.955					-0.834					-0.370				
Profile Area (mm^2)		103.355	102.268	101.908			24.825	24.959	24.113			145.525	146.951	150.707	
Avg. Wear (mm) Over Profile		0.263	0.260	0.259	0.261		0.063	0.064	0.061	0.063		0.370	0.374	0.383	0.376

APPENDIX C

DESCRIPTION OF CONCRETE SPECIMENS

CONTENTS:

APPENDIX C.1: Fabrication of Large Concrete Cylinders for Determining Resistance of Concrete to Ice Abrasion and Impact (contractor report provided by Concrete Laboratory Ltd)

APPENDIX C.2: In-Situ Testing of Large Contrete Cylinders for Abrasion Test (report provided by K. Painter, CANMET)

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APPENDIX C.1

FABRICATION OF LARGE CONCRETE CYLINDERS FOR DETERMINING RESISTANCE OF CONCRETE TO ICE ABRASION AND IMPACT

(Contractor Report provided by Concrete Laboratory Ltd)

CONCRETE LABORATORY LTD

October 22, 1990.

Supply and Services Canada
Science Branch
11C1, Place du Portage, Phase III
11, Laurier Street
Hull (Quebec)
K1A 0S5

Care of : Mr Robert McMillan
Science Contracting Officer

Your Reference n° : 09SQ.23440-9-9208
Our file n° : S6236
Report n° : 03B (1090)

Object : Proposal N° 09SQ.23440-9-9208
Fabrication of Concrete Cylinders
for Determining Resistance of Concrete
to Ice Abrasion and Impact

Dear Sir,

Please find here-in our final report regarding this project.

Sincerely,

André Bisaillon, Eng.

AB/fh

p.j.

QUALITY CONTROL - MATERIALS TESTING
3420 East, St-Joseph blvd., MONTREAL, Qc H1X 1W6
Tel: (514) 255-0613, Telex 055-62366

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FABRICATION OF LARGE CONCRETE CYLINDERS FOR DETERMINING RESISTANCE OF CONCRETE TO ICE ABRASION AND IMPACT

(FOR OF THE PROGRAM OF THE FEDERAL PANEL ON ENERGY R & D)

1. OBJECTIVE

The present report covers the preparation of large size specimen with four non-air entrained concrete mixtures to be proportioned to provide 15, 25, 35 and 45 MPa compressive strength at 28 days using local normal weight limestone and CSA type 10 cement. The large size specimen are cylinders 30 mm in diameter and 500 mm long with a 87 mm steel shaft in the central axis. For each strength two specimen were cast; one with a smooth surface and one with a rough surface.

The concrete was tested for compressive strength and elastic modulus and the results are given in this report with the characteristics of the fresh concrete.

2. WORK SCHEDULE

Our contract was awarded on the 26 of February. The specimen were to be delivered to Fleet Technology for the 6 of April. Since 28 days of curing were required this left less than 2 weeks to cast the specimen. To accelerate the work, a subcontract was given to Fleet Technology, a previous fabricator on a similar contract, to manufactured the steel shaft and reinforcing steel required for the cylinders.

The shaft were received on Monday the 19 of March and we schedule the casting of the specimen for the 21, 23, 26 and 28 of March. Unfortunately the casting of the specimen had to be cancelled on March 21 because the diameter of the shaft had been change and that they would not fit in our moulds. In the few days that followed we had several conversation with the representative of Fleet Technology to find the most appropriate solution. Finally we were instructed to have the mould remachined to fit the diameter of the shafts. We located a subcontractor that accepted the work and delivered the moulds on the 24 of April. The casting of the specimen was done as shown on table 1.

3. CASTING OF TESTS SPECIMEN

Concrete mixes for all types of concrete were prepared in 0,16 m^3 batches, using mix design formulae shown in table 2.

All materials were pre-weighed and placed in sealed bags. Before mixing, humidity content of the aggregates was measured and all materials were re-weighed.

The materials were batched according to CAN/CSA A23.2-2C.

Concrete was cast in steel moulds in which a steel shaft and reinforcing steel (photo 1) were secured by means of a hole at the bottom of the mould and a steel collar above the mould (photo 2).

Two types of plastic lining were installed in the moulds to simulate smooth (photo 3) and rough (photo 4) surface textures.

All joints in the mould were sealed with a caulking (photo 5) to insure uniformity of the surface (photo 6) and prevent loss of paste.

Concrete was placed in 15 cm layers and each layer-vibrated with a 20 mm diameter internal vibrator. After vibration of each layer the mould was struck wigh a hammer around its outside circular surface to evacuate air bubles on the inside surface.

From each batch two 500 mm x 300 mm diameter specimen were cast one of each texture for abrasion and impact testing. Fifteen 300 mm x 150 mm diameter were also moulded from the same batch of concrete for testing at 3, 7, 28 and 91 days with three cylinders being tested at each age. The testing of the extra cylinders was done at the some age as the abrasion test on the large specimen.

After 24 hours the concrete specimen were stripped of the mould, placed in the curing room, at 23°C and 100% relative humidity (according to CSA CAN3-A23.2-3C) for 28 days after which they were shipped to Fleet Technology.

TABLE 1

SCHEDULE

TEST N°	STRENGTH	SPECIMEN N°	DATE OF CASTING	EXPECTED DATE OF SHIPPING
6236-06	15 MPa	06-A	04/27/90	05/21/90
		06-B	04/27/90	05/21/90
6236-07	25 MPa	07-A	04/30/90	05/21/90
		07-B	04/30/90	05/21/90
6236-08	45 MPa	08-A	05/02/90	05/21/90
		08-B	05/02/90	05/21/90
6236-09	35 MPa	09-A	05/04/90	05/21/90
		09-B	05/04/90	05/21/90

TABLE 2

BASIC MIX FORMULAE

(AS DETERMINED IN TASK 3)

Mix n°	06	07	08	09
Concrete strength, MPa	15	25	45	35
Nominal size coarse aggregate, mm	---------- 20 mm ----------			
Type of aggregate	---------- normal weight ----------			
Quantities				
Cement, kg	255	345	570	420
Water, kg	190	190	200	190
Coarse aggregate, kg	1 000	1 000	1 000	1 000
Sand, kg	1 000	850	630	780
W/Cement	0,745	0,550	0,350	0,450
Slump, mm	---------- 80 mm ----------			
Air Content, %	---------- 6% ----------			
	3,0	2,5	2,0	2,5

4. PHYSICAL PROPERTIES OF AGGREGATES

4.1 Normal Weight Coarse Aggregates (Demix Quarry Laval)

	10 mm	14 mm	20 mm
Specific Gravity :	2,74	2,76	2,73
Absorption :	0,7%	0,4%	0,6%

4.2 Normal Weight Fine Aggregates (St-Gabriel de Brandon)

Specific Gravity : 2,69
Absorption : 0,7%
Fineness Modulus : 2,51

4.3 Sieve Analysis of Sand

SIEVE SIZE	% PASSING	CSA SPECIFICATION % PASSING
10	100	100
5	99	95-100
2,5	90	80-100
1,25	72	50-90
630	42	29-65
315	7	10-35
160	1	2-10
80	0,4	0-3

4.4 Sieve Analysis of Normal Weight Coarse Aggregate

SIEVE SIZE	% PASSING 32% 20 mm 50% 14 mm 18% 10 mm	CSA SPECIFICATION % PASSING
28 mm	100	100
20 mm	93	90-100
14 mm	65	-
10 mm	29	25-60
5 mm	4	0-10
2,5 mm	0,1	0-5

5. RESULTS OF TESTS ON THE CONCRETE

Date of casting	04/27/90	04/30/90	05/02/90	05/04/90
Concrete strength MPa	15	25	45	35
FORMULA (kg/m^3) 6236-	06	07	08	09
Cement	245	323	571	426
Water	183	190	206	193
Coarse agg. 20 mm	308	320	320	325
Coarse agg. 14 mm	480	499	501	508
Coarse agg. 10 mm	961	849	631	792
Sand	173	180	180	183
W/C	0,745	0,551	0,362	0,452
RESULTS				
Slump (mm)	60	120	120	110
Air content (%)	4,0	3,0	2,2	2,8
Temperature (°C)	20	21	20	21
Unit weight (kg/m^3)				
Theoretical	2350	2385	2400	2390
Fresh	2350	2360	2410	2427
14 days	2385	2384	2416	2414
Compressive Strength, MPa				
3 days	7,5	15,7	31,0	25,4
	7,7	15,9	34,1	25,4
	7,8	16,3	34,5	26,6
7 days	11,7	24,7	36,6	28,8
	12,9	25,9	37,3	29,2
	12,9	26,3	39,3	32,4
28 days	18,8	30,7	47,3	37,8
	19,5	32,0	48,3	40,0
	19,8	32,9	49,3	40,7
91 days	20,3	31,5	47,5	41,5
	20,8	33,7	49,8	42,8
	21,3	34,6	50,3	44,8
Extra cylinders	175 d	100 d	134 d	168 d
	23,5	34,0	49,8	42,7
	24,4	34,0	53,3	43,2
	24,6	36,0	55,4	45,3

5. RESULTS OF TESTS ON THE CONCRETE (CONT'D)

Modulus of elasticity, MPa X 10^6

28 days	29030	28830	30805	27135
	26450	31210	32240	32500
Average	27740	30020	31520	29820

Poisson's ratio

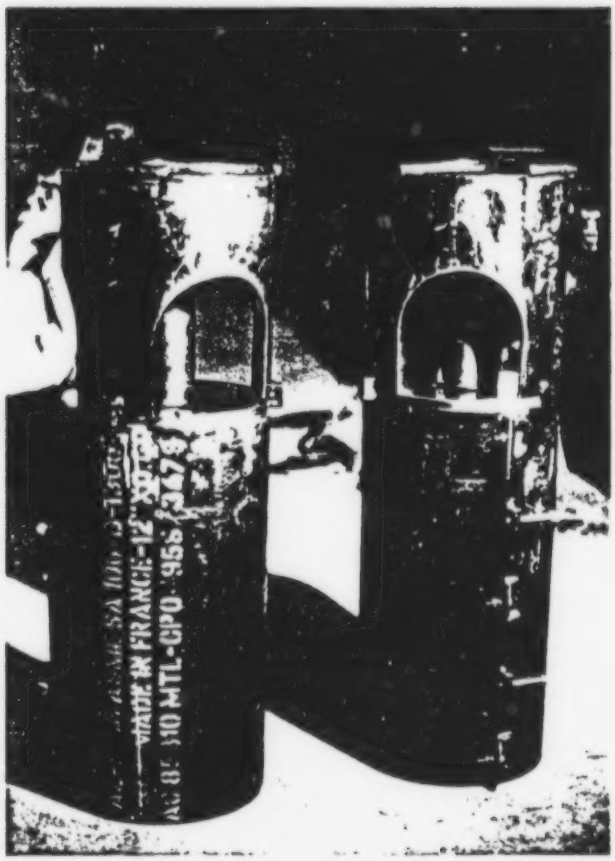
28 days	0,25	0,23	0,24	0,21
	0,23	0,21	0,26	0,26
	0,24	0,22	0,25	0,24

APPENDIX "A"

PHOTO NO 1

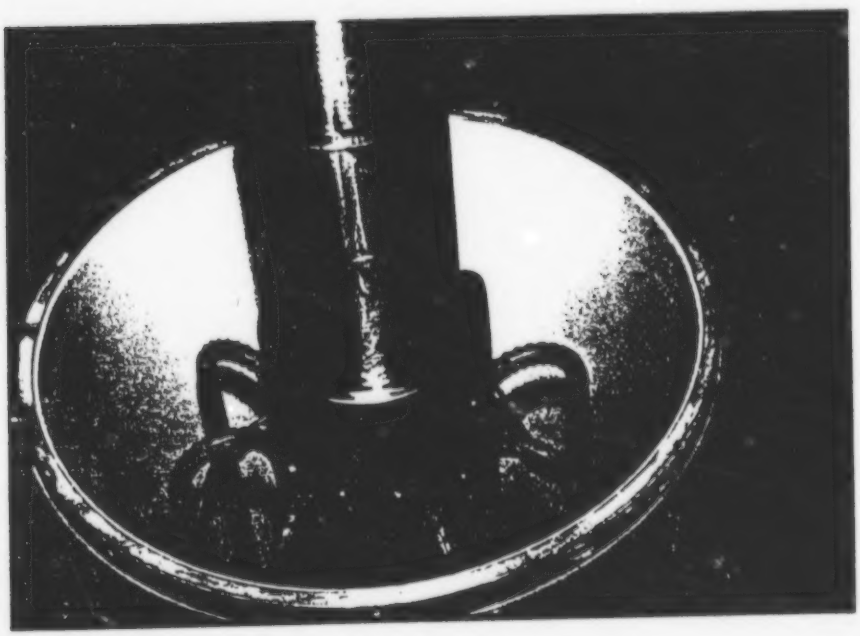
STEEL SHAFT AND REINFORCING STEEL

PHOTO NO 2



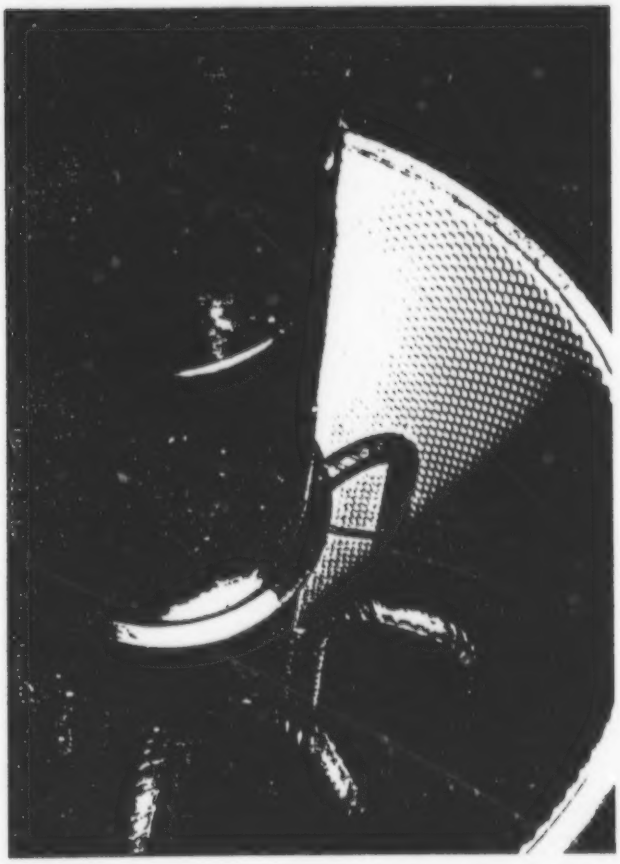
MOLDS WITH SHAFT SECURING DEVICE

PHOTO NO 3



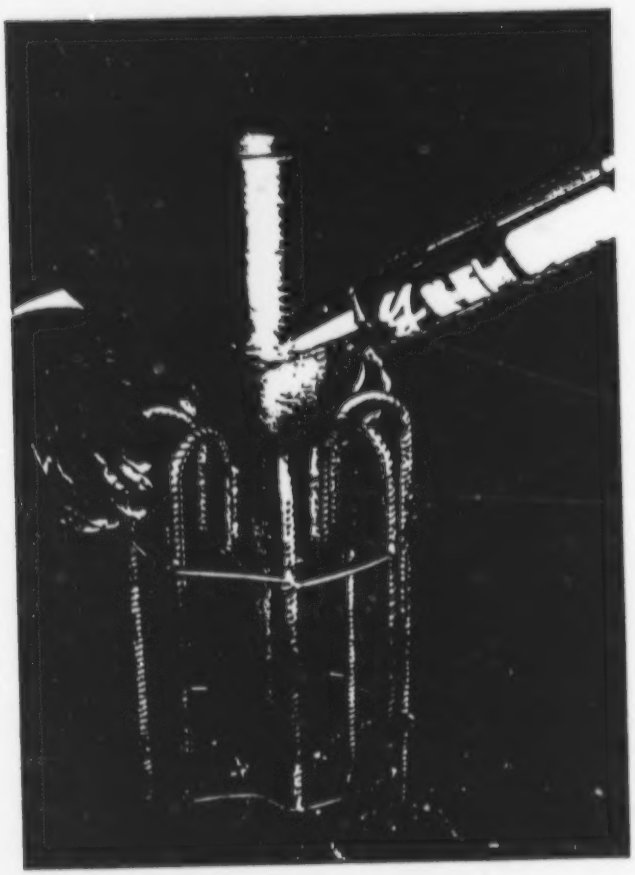
SMOOTH TEXTURE PLASTIC LINER

PHOTO NO 4



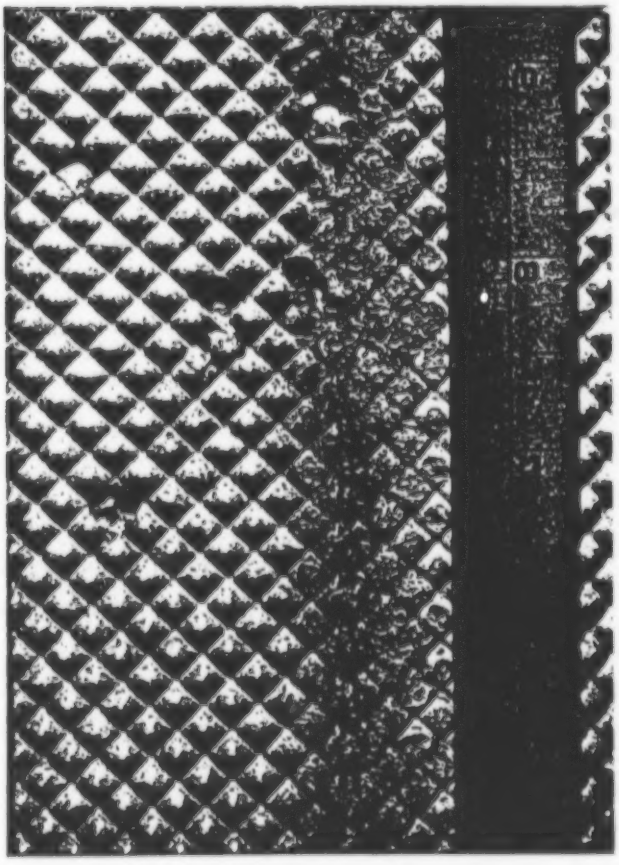
ROUGH TEXTURE PLASTIC LINER

PHOTO NO 5



APPLICATION OF SEALER ON SHAFT

PHOTO NO 6



TEXTURE AT MOLD VERTICAL JOINT

APPENDIX C.2

IN-SITU TESTING OF LARGE CONCRETE CYLINDERS FOR ABRASION TEST

(Report provided by K. Painter, CANMET)

Government of Canada / Gouvernement du Canada

MEMORANDUM NOTE DE SERVICE

To / De: George Comfort
Manager, Cold Regions Technology Center
Fleet Technology Ltd.

From / De: K.E. Painter
Sr. Technologist, Concrete Technology Sect.
M.S.L.

Security Classification – Classification de sécurité

Our File – Notre référence

Your File – Votre référence

Date: November 16, 1990

Subject / Objet: IN-SITU Testing of Large Concrete Cylinders for Abrasion Test

Please find enclosed two tables summarizing the non-destructive testing (ie. Schmidt hammer test and pulse velocity measurements) on the cylinders before and after the ice abrasion test, Table 1 and Table 2, respectively.

I have also included some literature relating to these tests from a CANMET report by V.M. Malhotra based on work that was done in our laboratory. Perhaps you can use this information to extract some basic conclusions about the integrity of the test specimens before and after the abrasion testing. Once you have made your conclusions perhaps you would call me and we can discuss them.

Again, my apologies , the delav in forwarding this data to you was due, for the most part, to some very pressing cost recovery work that I'm involved in.

Canada

TABLE 1 - Summary of rebound number and ultrasonic pulse velocity of test specimens before the start of the ice abrasion test.

Compressive Strength MPa	Surface Texture	A. Rebound Number*			B. Ultrasonic Pulse Velocity**		
		Rebound Number			Pulse Velocity, m/sec.		
		1	2	3	1	2	3
15	Smooth	28	29	29	4550	4620	4465
	Rough Hatch	21	20	20	4605	4525	4495
25	Smooth	33	30	33	4595	4515	4640
	Rough Hatch	22	23	22	4585	4535	4550
35	Smooth	36	35	34	4610	4600	4535
	Rough Hatch	24	23	23	4570	4630	4630
45	Smooth	41	39	40	4700	4710	4690
	Rough Hatch	25	24	25	4815	4720	4630

*Each value represents the average of seven hammer rebound readings taken from nine readings in which the high and low readings in each case were discarded.

**Path length = 50 cm.

TABLE 2 - Summary of rebound number and ultrasonic pulse velocity of test specimens after the completion of the ice abrasion test.

A. Rebound Number*

Compressive Strength Mpa	Surface Texture	Rebound Number 1	2	3
15	Smooth	20	22	19
	Rough Hatch	20	21	19
25	Smooth	29	28	26
	Rough Hatch	21	22	22
35	Smooth	39	37	33
	Rough Hatch	27	25	24
45	Smooth	38	34	40
	Rough Hatch	23	28	27

B. Ultrasonic Pulse Velocity**

Surface Texture	Pulse Velocity, m/sec. 1	2	3
Smooth	4235	4165	4030
Rough Hatch	4095	4190	4105
Smooth	4190	4140	4175
Rough Hatch	4395	4410	4355
Smooth	4650	4690	4605
Rough Hatch	4650	4690	4690
Smooth	4655	4615	4700
Rough Hatch	4650	4650	4690

*Each value represents the average of seven hammer rebound readings taken from nine readings in which the high and low readings in each case were discarded.
**Path length = 50 cm.